THE HAWAIIAN
PLANTERS' RECORD

Volume XXVII. OCTOBER, 1923 Number 4

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Notes on Armyworms and Cutworms

The accompanying pictures show armyworm and cutworm damage at Honokaa this year. These are of Uba cane and represent the condition of several hundred acres of mostly D 1135 fields. Most of the damage was done to the young cane extending from about 800 feet elevation to the highest fields. This severe check must cause a very considerable retarding effect, for most of the leaf-tissue was removed.

The common armyworm *Cirphis unipuncta* was mostly responsible for the damage. Thousands of the larvae were present on the cane, grass and ground about the fields. The expected second generation from these did not materialize. Moths hatched out in fair quantity, but few eggs were placed on the cane or grass in the cane fields. At present only a single worm at wide intervals can be found.

At the close of the outbreak some of the natural enemies of the caterpillars were conspicuous. The large yellowish *Polistes* wasps were particularly numerous and were very busily skinning the larvae and carrying the partially chewed skins to their paper nests. A few days ago, while riding along the main ditch through young fields of cane, I counted 500 of these wasps passing in front of me in twenty minutes' time. The two important Tachinid parasites *Frontina archippivora* and *Chaetogaedia monticola* have also been numerous, particularly the former. On June 8th I took twelve of the armyworms from the field and placed them in a jar with grass. None matured, but from each one there emerged a *Frontina* maggot after the caterpillar had died.

Several poison-baits were tried by Mr. E. E. Naquin, but only one proved highly successful. Success was obtained with the standard mixture of Paris green and finely powdered air-slacked lime, mixed in the proportion of one part Paris green to eight parts lime and applied to the cane in dry dust form. By partially filling a sugar sack with the mixture and shaking the closed bag over the cane, the dust was very evenly and thoroughly distributed. Most of the larvae present when this was applied died. The Honokaa Sugar Company has now on hand a large stock of the poison to apply in the above method in case of future outbreaks of cutworms and armyworms.

Judging from the results obtained in poisoning with the dust-mixture, I am very much in favor of this method over the old way, where a moist bran or bagasse mash is applied containing the poison. This did not work nearly as well as the dry mixture.

C. E. P.

The Root-Rot Problem Up to Date

By H. L. Lyon.

A malady characterized by the destruction of the root system followed by the collapse of the aerial portion of the plant is known in the pathology of a great many cultivated plants. This malady passes under various names, but "Wilt," "Root disease" and "Root-rot" are the names most often employed. The disease of this nature in pineapples and in cotton is known as "Wilt"; in sugar cane it is called "Root-disease" and "Root-rot".

There is no reason to believe that the cause of root-rot is the same in different species of plants or even that it is always the same in any one species, but a complete understanding of the disease in any species would be of great assistance in the investigation of the similar disease in other plants for it would indicate a line of attack that might be expected to produce results.

In the following pages, we strive to indicate the present status of the root-rot problem by recounting the findings and quoting the opinions of investigators who have recently worked and published on the subject.

Root Disease and Root-rot in Java

In 1895, Wakker described a new soil-dwelling fungus, *Marasmius Sacchari,* which he said was responsible for a disease of sugar cane in Java. There was no doubt but that he found this fungus growing as a parasite on sugar cane plants, attacking their roots and the underground portions of their stalks. The Java planters and their scientific advisers, however, recognized a malady which was distinct from Wakker's "root-stalk" disease because it occurred far more extensively than did *Marasmius* and was not attended by certain symptoms always created by this fungus. In 1898, the Java planters became so alarmed by the widespread occurrence of root-rot that they raised a fund to support an intensive investigation of the malady. Dr. Z. Kamerling was selected to devote all of his time to the study of root-rot and a special root-rot laboratory was created and maintained for several years. During the years 1900 to 1903 inclusive, several papers appeared on root-rot in Java and in the last named year, Kamerling published a book of some two hundred pages on the subject. He suggested that the cause might be poor aeration of the soil, but his main idea seemed to be that the trouble was in some way due to mechanical injury of the roots by the soil particles. His thesis is lacking in tangible evidence and tangible conclusions.

After the publication of Kamerling's work, the investigation of root-rot seems to have lagged in Java for many years, due, no doubt, to the fact that the old Cheribon variety was being replaced by seedlings which were far more resistant to root-rot. In recent years, a seedling cane known as E. K. 28 has become the leading cane variety in Java and now occupies fully 40 per cent of the total cane-growing area in the island. This seedling is very subject to root-rot, however, and in 1921 the disease became so prevalent in E. K. 28 that some expressed fears that the variety would be eliminated altogether. This scare caused many growers

to turn from E. K. 28 to other more resistant varieties in their plantings for the 1922 crop.

In an attempt to reassure the planters and restore the standing of E. K. 28, Dr. J. Kuyper* has recently published a lengthy dissertation, in which he tries to demonstrate that the fear of root-rot in this favored variety is unfounded. He does not seek to do this by definitely proving the cause of root-rot and offering a specific remedy, but strives, by recounting field observations and statistics, to show that the occurrence of root-rot is limited to soils of a certain nature; that it had reached the maximum spread possible in E. K. 28 in 1921; and that even with root-rot present in certain sections E. K. 28 still gave a better average yield than any other variety.

Dr. Kuyper's description of root-rot in Java tallies very closely with the symptoms of the disease as displayed by Lahaina cane in Hawaii. He asserts that the malady occurs in practically all the cane varieties of Java.

Dr. Kuyper seems quite confident that he knows the cause of root-rot, but in the present paper he brings forward only circumstantial evidence to support his opinion. His explanation may seem sufficient to those familiar with the disease in Java only, but it certainly will not carry conviction to those studying root-rot of cane in countries other than Java. He states that the disease is:

. . . caused by a lack of oxygen, by temporary or constant anaeroby, as for instance in a soil supersaturated with standing water and, therefore, low in oxygen. We mention standing water particularly because the water percentage may be high without being harmful as long as the water itself is in motion and can always supply oxygen, such as sometimes happens very remarkably during floods. This anaerobic root-rot occurs most typically on heavy soils where the drainage is poor; the oversupply of standing water can be caused here by too much irrigation, by floods or by too high a water level. . . . . .

But besides this anaerobic root-rot, the disease also occurs on lighter soils where we can hardly speak of anaerobic conditions; we have in mind the soils in Probolinggo, in Kediri, where the structure is such that we have the tendency to speak of good soils and sometimes even of very good soils but here the chances of root-rot are always great. In Wonolangan, Oemboel and Soemberkareng, gravel soils occur which look exceptionally good and yet they are among the most feared soils, especially for E. K. 28. It is mostly the fairly moist soils, soils of the hot-house type, soils which heat quickly. Thus far it has not been possible to characterize these soils sufficiently through bacteriological or chemical analyses to designate them specifically. Reduction generally cannot be shown; we could, therefore, speak of aerobic root-rot. But the two types cannot be kept separate very sharply, they are often mixed and it must be remembered that even in light soils a temporary anaeroby can exist through excess of water which often starts the disease. But based on our experience *in the great majority of root-rot cases an excess of water in the soil is the first cause to think of;* in a great many cases, even on light soils a temporary excess of water could be shown as the detrimental element with a fair degree of certainty. It is quite remarkable that root-rot practically does not occur on the dry lands of Kediri, nor on the so-called dry rice lands, that is on rice fields to which no water is applied during the East monsoon; whereas on ordinary rice lands in the same region, root-rot occurs frequently.

A factor of decided influence upon the occurrence of the disease is a change in the moisture content of the soil; it still remains a question as to whether or not this is a primary factor, but that a plant once affected with root-rot reacts much stronger to the disease in a soil showing marked variation in moisture content than it does in a soil showing but small and gradual changes in this respect may be taken as a fact. This explains why we find less diseased fields in clay soils than we do on lighter soils in the same neighborhood. For instance, it is peculiar that regions with light soils, such as certain parts in Probolinggo, Kediri, and large parts of

*Kuyper, J. Het wortelrot op Java, speciaal in verband met de rietsoort E. K. 28. Mededeelingen van het proefstation voor de Java suikerindustrie. Jaargang, 1923, No. 4.

Djokja and Solo, often have root-rot, whereas regions with much heavier soils in other provinces at practically the same elevation, the disease is much less noticeable. Uniformly moist regions such as Banjoemas, show little root-rot. . . . . . .

This brings us to the phenomenon which we call "dry root-rot." In a great many cases of root-rot, bibit-rot* plays an important part. . . . . . .

In bibit-rot, substances poisonous to the plant develop in the bibit which, under certain conditions, the shoot is forced to absorb. Such circumstances are in general induced by the failure of the roots to furnish a sufficient water supply and this in turn may be caused by the ordinary wet or anaerobic root-rot, but it may also be caused by dry root-rot when the plants, with a poor root system on which falls a heavy duty because of drought, are forced to take the moisture present in the bibit or in the remains of the bibit. Dry root-rot may be considered as bibit-rot but differs from ordinary suffering from drought because the root system is in an unhealthy, insufficient condition. The basic cause of dry root-rot is, therefore, the same as for any other root-rot. . . . . . .

We pointed out before that the main cause of root-rot is an oversupply of water. In each individual case this cannot always be demonstrated with certainty but such has practically been accepted in practice. . . . . . .

However, as stated in the beginning, there is also an aerobic root-rot; a root-rot in connection with which no lack of oxygen or reduction can be demonstrated. The explanation must probably be looked for in another direction.

Dr. Kuyper calls attention to the very evident resemblance of sugar cane root-rot to the "wilt" or "root-rot" of barley in the Netherlands. Experimenters had shown that this barley disease could be controlled in cultures by the addition of manganese sulphate.

A great number of tests with manganese sulphate were carried out in Java in 1921. The Experiment Station supplied the manganese sulphate and fifty-three plantations took the trouble to experiment with it in one or more fields. Only one plantation reported indications of beneficial action and investigations proved that even here the results were, to say the least, doubtful; and we may safely say that $MnSO_4$ has failed as a remedy for root-rot.

Dr. Kuyper states emphatically that no proof has been found either in Java or in any other country that a certain parasite is the cause of the root-rot. He speaks of the disease in Hawaii as follows:

We wish to call attention to the fact that root-rot also occurs in other countries, for instance in Hawaii, where they have looked energetically for vegetable or animal parasities but so far have not succeeded. In the Hawaiian Planters' Record, 23:142, 1920, Carpenter gives an extensive study on the possible connection between Lahaina disease, which corresponds closely with root-rot, and *Pythium*, a well-known fungus. The infection experiments do give indications that this fungus had something to do with the disease but they are far from convincing. Carpenter acknowledges himself to be in a doubtful attitude. . . . . .

And finally Carpenter states that a similar fungus is found in diseased roots of other plants such as cannas, colocasia and rice. This seems to indicate again that he is dealing with a widely occurring fungus which acts detrimentally only under definite circumstances.

Root Disease in the West Indies

Root disease appeared in the Bourbon (Lahaina) cane in the West Indies in the early seventies of the last century, and gradually rendered unprofitable the cultivation of this old favorite variety.

Howard[1] was the first plant pathologist to give serious attention to the cane diseases of the West Indies. He held the disease of the Bourbon cane to be the same as the root-disease of the Cheribon in Java and as he found the fungus *Marasmius sacchari* of Wakker to be present, he concluded that it was the cause

*Bibit = seed or cutting.

[1]Howard, A. On Some Diseases of the Sugar Cane in the West Indies. Ann. Bot. 17:373-411, 1903.

of the malady. Since Howard's work appeared, many pathologists have studied the root disease of cane in the West Indies, but, until recent years, they have, without exception, accepted Howard's conclusions and held *Marasmius* to be the cause.

In 1917, Johnston and Stevenson[1] after working on cane diseases in Porto Rico wrote:

The exact status of root disease with respect to the parasitism of *Marasmius, Himantia, Odontia,* or possible other forms, is uncertain and while it is generally held that *Marasmius* at least is a true parasite, really definite evidence is lacking.

In summing up the work on root disease which had recently been done at the Insular Experiment Station in Porto Rico, under his direction, Earle[2] tells us that "*Marasmius* is at best a very feeble parasite" and "The killing of the roots which is so marked a feature in 'root disease' is usually caused by various species of *Rhizoctonia* and sometimes by a species of *Pythium.*"

The most recent opinion on root disease emanating from the West Indies is set forth in a paper by Bourne[3] which has just come to hand. He gives the details of inoculation experiments which he maintains furnish:

Formal Proof of Pathogenicity of:

1. *Rhizoctonia solani* and
2. *Rhizoctonia palida.*

There is no doubt that root disease is due to one or the other of the above fungi as determined by the following points:

1. The constant association of one or the other of the above fungi with the disease and their isolation from typical diseased tissue of the host.
2. Healthy sterilized cuttings when inoculated with pure cultures of either of the above fungi in sterilized soil produced plants having characteristic signs of the disease. The penetration of the fungi into the roots has also been observed.
3. The fungi have been re-isolated from inoculated diseased roots and when compared in culture with the fungi used for inoculation were identical with them.

Bourne inoculated healthy plants with the two fungi mentioned but, judging from his photographs, he did not obtain anything like as striking results with his *Rhizoctoniae* as Carpenter did with his *Pythium* here in Hawaii in experiments conducted along the same lines.

Root-Rot in Hawaii

Lewton-Brain, coming to Hawaii from Barbados, where he had worked on root disease of the sugar cane, pronounced the malady in Hawaii identical with that in the West Indies; and considered his contention substantiated when he found fructifications of *Marasmius sacchari* in Hawaiian cane fields.

After a brief survey of the situation, Cobb reached the conclusion that *Ithyphallus coralloides* was the most important root-destroying fungus but that *Marasmius* and the so-called "stellate-crystal fungus" also contributed to root disease.

An intensive study of root-rot in the field and laboratory conducted by Larsen and Lyon served to demonstrate that *Ithyphallus* and *Marasmius* had no primary connection with epidemic root-rot in Hawaii and that other fungi were responsible for the destruction of the cane roots. These fungi were taken up in turn but

[1] Johnston, J. R., and Stevenson, J. A. Sugar Cane Fungi and Diseases of Porto Rico. Journal Dept. of Agric. of Porto Rico. 1: 177-251, 1917.

[2] Earle, F. S. Sugar Cane Root Disease. Journal Dept. Agric. of Porto Rico 4:3-27, 1920.

[3] Bourne, B. A. Researches on the Root Disease of Sugar Cane. Dept. of Agric., Barbados. Forwarded to the Government for publication in August, 1922.

each failed to qualify under test as the primary cause of root-rot. Finally by transferring diseased cane stools from diseased to healthy fields, it was demonstrated that these fungi could not materially check the growth of the cane plant if the soil conditions were right. Evidence deduced from extensive field studies and the many experiments performed seemed to prove that the real cause of root-rot in Hawaii was some non-parasitic factor resident in the soil and to indicate that this factor was in the nature of a poison.

The Experiment Station then undertook to determine the nature of this poison and a means of counteracting it. The first clue obtained pointed to black alkali as the toxic ingredient in the soil. This lead was consistently followed until it was definitely proven that we were on the wrong track.

Following the collapse of the black alkali theory, interest in root-rot waned somewhat because seedling canes resistant to root-rot were being rapidly substituted for the susceptible Lahaina with most satisfactory results.

In 1919, root-rot in an aggravated form appeared in the seedling cane H 146. The affected stools were growing in a well-drained, virgin soil and were being irrigated with mountain water. While the appearance and spread of the disease in a seedling cane growing under such conditions did not refute the poison theory, still, it strongly suggested the work of a parasite and we again made a search for an organism of this nature. Examination of living roots revealed the presence of a new chytridiaceous fungus which was evidently responsible for the destruction of the roots in this particular case. This same fungus was found in the roots of diseased Lahaina cane growing under similar conditions and we at once suspected that it might be the universal cause of root-rot which had previously escaped detection because of its minute size and evasive habits. A search for this organism in other fields where root-rot was most prevalent failed to reveal its presence, however, and we were finally forced to class it with the other parasitic root fungi as virulent only under certain conditions. Of all the fungi credited with ability to attack cane roots this one only is strictly parasitic. It cannot, like all of the others, live on decaying vegetable matter, but feeds only on the living substance of some other plant. In attacking a cane root, it penetrates the growing point and destroys the embryonic tissue located here. In so doing, it effectually stops the growth of the root. Its migration through the soil is so dependent upon special conditions that we might reasonably expect its distribution to be limited rather sharply and this apparently is the case.

Carpenter began working on the root-rot of sugar cane at this time and concluded that the fungus *Pythium* was the cause of the malady. He performed some of the most careful and elaborate cultural and inoculation experiments that have ever been conducted in the study of root-rot of sugar cane; and by the evidence produced he comes nearer proving his contention than has any other pathologist who held a fungus to be the primary cause of the disease.

Carpenter proved that his *Pythium* could act as a parasite attacking the living roots of the cane, and that in so doing, it would seriously retard the growth of a plant. It would not cause the complete collapse of the plants in his experiments, however, even after their vigor was reduced through confinement in pots. More-

over, this *Pythium* is of very general occurrence in the soil throughout the cane fields of Hawaii and not present only where root-rot occurs.

During the latter part of the war, a peculiar disease appeared in the potato fields of Maine. At first, it was thought to be caused by a parasitic organism, but its occurrence was soon correlated with the use of a certain fertilizer. It was found that the trouble was due to borax which accompanied the potash that was being applied in large doses. The potato plant, it seems, is seriously affected by the presence of very small quantities of borax in the soil. As this compound might have been included in fertilizers used in Hawaii, the Experiment Station inaugurated experiments to determine the effect of borax on the cane plant. In tests conducted by the chemists, it was found that cane would tolerate a much higher concentration of this compound in the soil than could possibly have been attained, even though highly contaminated fertilizers had been used. It is evident, therefore, that borax cannot be considered the cause of root-rot in cane in any case.

The Experiment Station is now engaged in determining the possible toxicity to sugar cane of soluble aluminum compounds in the soil. It may quite possibly be that aluminum poisoning is the primary cause of root-rot, for information in hand points strongly in this direction. Investigation along this line was suggested by the work of Hoffer and Carr[1] on the root-rot of corn, an account of which has but recently appeared. These investigators found that corn plants suffering from root-rot always showed peculiar discoloration in certain tissues of their stalks. By experimentation, they found that they could produce similar, if not identical, discoloration by injecting solutions of certain salts of aluminum and iron into normal plants. They then developed methods whereby they could test the tissues of corn plants for the presence of iron and aluminum and found that diseased plants always contained these elements in abnormal quantities. This fact was corroborated in chemical analyses of healthy and diseased plants. They therefore concluded that root-rot in corn was primarily due to the poisoning of the plant through the absorption of toxic quantities of soluble iron and aluminum compounds from the soil. Acting on this hypothesis, they found that applications of lime and phosphates to the soil were very efficacious in preventing or controlling the root-rot of corn. In this connection, they write as follows:

> When lime is added to acid soils it is believed that the conditions which operate to make the aluminum and iron compounds available are destroyed, and even though aluminum salts may still be available after calcium carbonate is added, the addition of soluble phosphates will rapidly precipitate the aluminum salts and render the aluminum inert so far as absorption by corn plants is concerned.

The exact scope of their work and its bearing on our problem may be judged from their own summary, which we quote below:

> (1) One of the most characteristic differences between normally growing corn plants and those which become severely root-rotted is the condition of the vascular plate tissues in the nodes of the stalks. The plants which become severely root-rotted are those which have the nodal tissues discolored and in various stages of disintegration.
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> (2) This disintegration of the nodal plate tissues begins in the absence of any specific organisms in the tissues.

[1]Hoffer, G. N. and Carr, R. H. Accumulation of Aluminum and Iron Compounds in Corn Plants and Its Probable Relation to Root-rots. Journ. Agric. Research 23: 801-824, 1923.

(3) The brown, yellowish brown, and brownish purple discolorations with their consequent disintegrations which are frequently found in diseased plants have been produced artificially by injecting solutions of certain salts of aluminum and iron into the plants. Definite chlorophyll and leaf-tissue changes have been produced also. Other factors, however, may operate to produce similar effects.

(4) These artificially induced changes in the plant parts closely resemble the phenomena which develop in plants growing in the field under conditions favorable to root-rots.

(5) The most severe cases of root-rots have been found in soils notable because of their deficiencies of lime and available phosphates.

(6) Such soils have variable quantities of salts of aluminum and iron available for absorption by plants.

(7) Corn plants show marked differences in the quantities of aluminum and iron salts which are absorbed by them. These differences develop when the salts are available in subtoxic concentrations in the soil and are believed to be due to specific selective capacities of different plants to absorb the available aluminum and iron salts from the soil. This type of selective absorption cannot operate when the aluminum and iron salts occur in quantities which are toxic to the roots.

(8) A definite cumulative toxicity of aluminum salts within the plants was established by the injection experiments, and it is believed that the same phenomenon occurs naturally in the field. The relative quantities of the available metals and of nitrates in the soil determine, in a large measure, the rate of development of the cumulative toxicity of the metals within the plants. Those plants which contain the largest quantities of these metals are the ones which seem to develop the most severe cases of root-rots when the organisms are present in the soil and the meteorological conditions favor their optimum growth.

(9) When abundant aluminum injuries occur in the corn plants in certain fields it is an indication that the soil is deficient in available phosphates.

(10) The application of lime and phosphates to soils in which root-rots have developed in destructive proportions has been decidedly beneficial in controlling them. The use of limestone alone in some instances proved harmful, but in all cases studied so far the application of available phosphates produced plants which were better and more resistant to the root-rots.

Summary and Conclusions

The final opinion expressed by the Java pathologists is that root-rot is due to the presence, for longer or shorter periods, of stagnant water in the soil. They do not believe that parasitic organisms are in the slightest degree responsible for the malady. The West Indian pathologists, on the other hand, are agreed that parasitic fungi are the primary cause of root-rot and that species of *Rhizoctonia* occupy a place of first importance among these parasites. The conclusion arrived at by Mr. Carpenter here in Hawaii is identical with that held by the cane pathologists of the West Indies except that he would consider *Pythium* rather than *Rhizoctonia* the leading parasite. The writer has proven, to his own satisfaction at least, that parasitic fungi play a secondary part only and that the inception of the disease is due to some non-parasitic factor resident in the soil, this factor most likely being in the nature of a poisonous chemical compound or toxin.

It is a fact recognized by all pathologists that the ultimate destruction of the tissues of the root system is brought about through the action of organisms dwelling in the soil. This is, of course, the fate of all roots that die from any cause whatsoever, so the decay of roots induced by organisms does not, by any means, prove that the death of the roots was due to these organisms. Among the organisms found in cane roots in areas where root-rot is prevalent are several forms with pronounced parasitic abilities. They are capable of attacking, and

do attack, live cane roots, bringing about the destruction of the latter. The only question is: can they, unaided, destroy the roots rapidly enough to produce root-rot in cane? Some pathologists say that they can, while others say that they cannot unless the vitality and resistance of the cane is first reduced or broken down by some non-parasitic factor in the soil. We are, therefore, confronted with two opinions regarding the primary cause of root-rot and we may profitably consider each in turn as correct and see what course should be followed under the circumstances.

If the disease is due primarily and entirely to the attacks of parasitic organisms, the only *cure* is some treatment of the soil that will destroy these parasitic organisms and prevent reinfection without hindering the growth of the cane. This is practically impossible, or, if possible, impracticable. The only salvation of the cane industry under this hypothesis then lies in the use of resistant or immune varieties.

If the disease is due primarily to some non-parasitic factor in the soil, we may be able to correct or eradicate this factor when once we have determined its nature and we shall then be able to grow Lahaina or any other variety of cane indefinitely. If we do not detect and counteract or remove this factor, it may continue to accumulate in the soil until our most tolerant varieties of cane succumb to its influence.

We have arrived at a temporary solution of the root-rot problem by employing resistant or tolerant varieties of cane. If the disease is due to parasitic organisms, we may reasonably expect that these varieties will remain resistant to the malady and our temporary solution will become a permanent solution of the problem. If the disease is due to a non-parasitic factor in the soil, the tolerance of any and all varieties of cane may eventually be exceeded and the entire failure of cane culture follow. During the past two years, well defined cases of root-rot have occurred in Yellow Caledonia, Yellow Tip, D 1135 and H 109. These are the resistant varieties which saved the industry when Lahaina failed because of root-rot.

If we accept the conclusion that root-rot is due entirely to parasitic organisms, we have all the necessary data at our command and can at once define the only logical course to follow. We can profitably abandon further search for parasitic root fungi, for there can be no possible doubt but that all of those associated with root-rot have been detected. There is no parasitic organism yet to be discovered, for it is easily demonstrated that the known organisms are the ones actually responsible for the decay of the roots. The question as to which fungus leads in the attack is of no practical importance. Treatment aimed at any one of them will be equally efficacious against all, but, since soil treatments offer no permanent relief from these fungi, the only means of defeating them is through the employment of resistant or immune varieties of cane.

If, on the other hand, we tolerate a suspicion that root-rot is induced primarily by some deleterious compound or toxin accumulating in the soil, we should make a desperate effort to detect this agent and to devise a means of rendering it harmless.

Adco Manures

Rothamsted Experimental Station

Mr. E. Hannaford Richards, who is experimenting with various materials in the so-called manufacture of artificial manure, has made tests with sugar cane trash and bagasse. He furnishes Mr. F. Muir the following data concerning these manures, which bear the trade name of ADCO. He makes the following comments:

No doubt your trash and bagasse will have very much the same composition as that from Mauritius. The analyses of trash and bagasse after fermentation are given on the sheet attached. Trash will make a better manure than bagasse. The latter is too woody and I do not regard it as a very promising material, especially as it is used as fuel, but any surplus might possibly be worked up with trash. The fine powder mentioned in the last paragraph of your letter can certainly be used in this way.

At present our information is limited to the fermentation of small samples of trash and bagasse in the laboratory. Until tests have been made on a practical scale it is very difficult to say how the manure will compare with your present method of supplying nitrogen to the soil from the economic standpoint. Assuming that trash will rot down on the large scale as it does in the laboratory, it is probable that the nitrogen applied in this form will give a larger return spread over several crops than is obtained from sulphate of ammonia applied direct to the soil. I quite realize that the conditions of the sugar industry in Hawaii may upset this conclusion, which is based on long experience of farm trials in England.

The obvious course is to get a trial carried out, and only then will it be possible to say whether the ADCO Process offers any decisive advantage over the older methods.

ANALYSES OF ADCO MANURES

Material Treated	Moisture	Nirtogen as Ammonia	Total Nitrogen	Phosphate	Potash	Loss on Ignition (Organic)	Ash
Bagasse	87.50	0.05	0.19	0.02	0.06	12.06	0.44
Trash	88.15	0.05	0.23	0.02	0.11	9.54	1.96
Wheat Straw......	76.00	0.07	0.52	0.13	0.14	18.86	5.14
Cow Dung (for comparison)	80.56	0.09	0.43	0.19	0.44	15.27	4.17

H. P. A.

Observations on Varieties on the Plantations

By J. S. B. Pratt, Jr.

During the past few months the writer has had the opportunity of observing seedlings and the old standard varieties on all the plantations. The following comments as to their behavior will be of interest to those places having these canes.

The largest change in varieties outside of the spread of H 109 is the extent to which D 1135 has increased, particularly on the island of Hawaii. Honokaa's area is practically all D 1135, and the plantations from there into Hilo are extending it as fast as they can get seed. It is rapidly replacing Yellow Caledonia as a middle belt and mauka land cane. Kau district is also extending it, and fields may be seen with very heavy cane with sticks large in diameter. It is able to withstand the severe conditions of the Hamakua district, and the old prejudice against it on account of harvesting costs is being lost with the increase in yields and the resultant decrease of cultivation costs. An experiment at Pioneer Mill, harvested this year, showed the superiority of this cane at the 600 ft. elevation under dry conditions. Oahu Sugar Company has an excellent field at about the same elevation near Kipapa Gulch. On the other hand, it has been dropped from Ewa completely, not competing with H 109 on the lower levels.

Yellow Caledonia on Kauai is being rapidly replaced by H 109 on the lower fields and with Yellow Tip on the upper fields. It is of the utmost importance that a cane be found that will take the place of Yellow Caledonia in the Hilo district should anything happen to that variety, as has happened to it on Kauai.

Yellow Tip is increasing in area as a mauka land cane but should be looked upon as a temporary substitute. Some variety more resistant to yellow stripe disease should be found.

Striped Mexican continues to be Wailuku's early cane, giving excellent juice there. It is on trial in a 50-acre field at Hawi. Pioneer finds it a very satisfactory cane for its conditions. However, a small plot looks very poorly at Grove Farm. Waianae is trying it. It became badly affected by Lahaina disease when tried at Ewa a number of years ago.

D 117 is rapidly losing favor on account of its falling down in yields on the ratoons.

Rose Bamboo, Yellow Bamboo, and H 146 have decreased areas.

Badila has found favor at Kilauea, Makee, Knudsen, Hakalau and Kohala. This cane requires moist conditions for optimum growth, and observations indicate that it does the best where we have the wet black soil, which is found in parts of the islands. Any cane needs good drainage, however.

Of the original H seedlings, only one has been developed to any extent. H 109 has increased until it now has 24 per cent of the Islands' cane acreage. It has become adapted to a wide range of conditions, but it has not found favor on Hawaii, where the colder, wet conditions make it a very expensive cane to raise. Hawi plantation will decrease its area, H 109 ratooning very poorly for them.

H146 for a time was being extended, but its ratoons did not come up to expectations, with the result that its area has been decreased rapidly. Waialua still reports excellent yields from it. H 146 is somewhat subject to Lahaina disease or at least some form of root-rot. As possibly four-fifths of our crop is in ratoons, our new seedlings must be able to give us good yields on the ratoons.

H 389 is being extended somewhat on the upper levels of Hilo Sugar Company. It is a cane much resembling D 1135, with larger sticks. On this plantation, as on many others, H 227 has a poor stand and will not be extended.

H 349 is found in a few acres at Ookala, and at Paauilo. The drawback to this cane is that it does not stool very heavily, but it does have very long sticks, giving enough tonnage to keep the variety.

Of the so-called H 400 varieties, H 456, H 472, H 468 and H 471 are the best. The objection to H 456 on several plantations that the variety does not ratoon does not seem to hold at Onomea, where it is doing exceptionally well. It is a cane with a broad leaf, a type desired in the Hilo district, and in the test at Onomea had an excellent quality of juice, as well as yield in cane. An abundance of moisture may be the factor required to make it a good ratooner. At the 1800 ft. elevation at Olaa, the acreage is being extended.

H 456 and H 472 both yielded better than Yellow Caledonia in a very exhaustive test with the 400 varieties at Grove Farm. Appearances indicate that these canes may have to be harvested early. H 472 we find well liked at Onomea, Koloa and Grove Farm.

H 463 was excellent at Hakalau and Grove Farm, but at the latter place recently showed that it has a weak resistance to invasions of fungi through the rind.

H 468, a Striped Mexican seedling, withstands the dry conditions of Waimanalo.

H 471 is a good cane on the upper lands of Onomea.

H 5001 looked promising for a time, but its inability to ratoon places it in the background.

The H 5900s have been tried out on all the Islands, with H 5965, H 5972, H 5909, H 5919, H 5922 and H 5923 the best. H 5927 was very badly affected by eye-spot at Pahala, and should be watched for this weakness. Perhaps the best of these 5900s is H 5965. We have noted its adaptability to Pahala, Honokaa and Waialua conditions. It was very good also at Hawi. H 5972 grows well under Kilauea and Pahala conditions, is a large cane with a big eye, but was affected by eye-spot badly at Waialua. Mr. E. E. Naquin, of Honokaa, reports that it also becomes badly affected by mosaic disease.

H 5919 ranked well with H 109 in a recent test at Ewa.

Some of the H 8900 seedlings look as promising as their parent, H 109. These have been tested on first ratoons at Waimanalo, Hawi, Waipio and Oahu Sugar Company. During the past few months they were well distributed on Kauai, Maui, and Oahu. The ones of most promise to date are H 8961, H 8973, H 8978, H 8965, H 8977, H 8973, H 8988, H 8948, H 8958, H 8994 and H 89102. This lot shows very great promise. The first four were better than H 109 at Waimanalo on first ratoons.

H 8949 is very badly affected by eyespot at Makiki.

H 5803 is a seedling of D 117, with many D 1135 characteristics. At our Manoa substation, at Koloa, Grove Farm, Ookala and Honokaa, we note that it is a cane that is worth watching. It has D 1135's character of being a good ratooner.

H 1801 was one of some promise at Manoa. It has not come up to expectations at Grove Farm, Koloa, Kaiwiki, Mr. Chas. Rice's or Honokaa. It gives a large number of germinations in the seedling nursery.

The Wailuku seedlings are proving adaptable to varied conditions. Wailuku already has ten to fifteen acres of some of these. It is interesting to note that some of the best ones at Wailuku were found to be worth extending at Koloa. These are W 2, 5, 9, 10 and 4. W 1 is a fast growing cane, but must be watched for mosaic disease. These seedlings are now on several places on Kauai, at Ewa, a few at Kahuku, at Puunene and Waipio.

Wailuku 2, when cut at eleven months had excellent juice and 55 tons cane per acre at Onomea. Here the ratoons have a good stand.

Of the many seedlings raised at Ewa, some twenty-five are being watched with interest. These are Ewa Nos. 177, 199, 225, 325, 362, 378, 380, 386, 387, 405, 421, 509, 555, 570, 700, 710, 712, 720, 731, 732, 737, 740, 759 and 569.

Hawaiian Sugar Company has raised a large number of seedlings. This plantation has numbered four of considerable promise of the 1918 propagation, Makaweli Nos. 1, 2, 3 and 4.

Honokaa No. 1 (OP 229-1917), a Striped Mexican seedling, is grown at Honokaa to the extent of fourteen acres, at all elevations. It resembles D 1135 in character of growth. The same cane has been extended by Olaa to several acres, but on the lower fields at Pioneer it looks very poorly. This is a strong example of the necessity of trying a cane out under all plantation conditions before it is discarded, and proves the contention that it is really on the plantations that the canes have to be developed.

Kohala Sugar Company has developed several canes that will be worth trying out on the mauka lands of Hawaii and Kauai. Kohala Sugar Company has ten to fifteen acres of some of these, and the following numbers are the most promising on the second ratoons: K 107, K 117, K 202, K 73, K 86, K 36, K 382, K 115, K 20 and K 101. These are largely D 1135 seedlings that have been crossed with Striped or Yellow Tip, and have many of the Tip characters that are desirable as cheap canes for mauka lands. At Onomea, we note that K 73 and K 86 are ratooning excellently at the 1000 ft. elevation, the former having the preference. Honokaa reports that 220 is the ranking Kohala seedling for their conditions. Seed of several of these Kohala seedlings is being raised at Manoa substation for distribution to plantations this coming spring. They are of the type desirable for mauka land canes, but their resistance to disease is not known.

Kohala No. 4 is making a fine start at Ewa and we are interested in seeing how this seedling makes out under warm, ideal conditions. It is not the type desired in the Kohala district.

As future mauka land seedlings, Mr. Jennings has put into the field this year some twenty-three thousand seedlings, largely of Tip and D 1135 crosses.

Several Badila seedlings are being tried out on Kauai and Hawaii. H 9811 is the best at Honokaa, and among the better ones at Kilauea. It is interesting to note that it is by far the best ratooner at Manoa on the second ratoons, and at Makiki plots it had a very heavy growth, with long joints. H 9804, H 9812 and H 9809 are among the better Badila seedlings.

The 1917 Oahu propagation seedlings were sent out to several plantations without having H numbers assigned. Pioneer Mill Company is carrying on some thirty of these. Ewa recently harvested these canes with 394-1917, an H 109 seedling, and 347-1917, a Lahaina seedling, comparing very favorably with H 109. No. 229-1917 is now Honokaa No. 1, and is also doing well at Olaa. Olaa is watching several of this lot, and Kilauea has a few of interest, but no harvesting data on their behavior has been obtained as yet.

Bud Selection

A Preliminary Report on Results and Methods

By J. A. Verret

Mr. Shamel is to write a report on the progress of the bud selection work for 1923. It is planned to have this report contain full details of the work being done, of the methods being recommended for use in this work, etc. As some of the material to be used will not be available for several months it will be late in the year before the report is out.

Progeny 1.

Progeny 2.

On this account we thought it might be of some advantage if we published at this time a short, preliminary outline of the 1923 developments in bud selection work. It occurred to us that the simplest way to do this would be to briefly describe some of the work actually done.

For this purpose we have selected a small progeny test consisting of five progenies, here at Makiki Plots.

General

In harvesting this area the weighing method adopted this year was used. Each stool was weighed separately, the number of stalks counted, and the length of row measured. From these data the average number of stalks per foot, the weight of cane per foot of row, the weight per stalk, the weight per stool and the estimated tons per acre were calculated.

These progenies originally consisted of one stool each from seed selected by W. W. G. Moir on Maui.

The following descriptions of these canes are from Mr. Moir's notes made at the time of selecting:

No. 1. Oval-stalked, semi-erect, large-eyed, strong white.

No. 2. Semi-erect, slender-stalked, small-eyed, orange.

No. 3. Erect, white, strong growth, medium to large stalk, medium eye.

No. 4. Semi-erect to erect, small-winged eye.

No. 5. Semi-erect to recumbent.

Type No. 1 was secured from some left over stalks that were to be exhibited at the Maui County Fair two years ago by Wailuku Sugar Company. I picked up the stalk from among several of type No. 4 and No. 5. Later I found out that the particular stalk came from a large prize stool (20 stalks) dug up at Waikapu, but which broke up before it was removed to the truck to be transported to the Fair grounds.

Progeny 3.

Progeny 4.

Type No. 2 was a stool of 12 stalks sent in by Waihee section of Wailuku Sugar Company for entry in the competition for the best Selected Stool but it was not entered because the stools from Waikapu were better. The stool was uniform, consistent throughout in regard to type, but for general desirability of type and excellence of growth it was poor.

Type No. 3 was a stool of 12 stalks growing in field G, Puunene, at the end of a level ditch. It would have taken a very high total of points if entered in the "Best Stool of Cane for Selection Purposes" class, but still would not have taken a first prize because of its slower growth and poorer total tonnage.

Type No. 4 }
Type No. 5 } Standard H 109 types secured in H 109 field (Field G Puunene). Under similar environments these two are practically identical but No. 4 would appear to have more vigor.

The stools showed differences in growth from the first. At the age of one year enough seed was selected to plant 50 running feet of each. This seed was planted in 5 rows, each 50 feet long. Ten feet of each progeny was planted in each row, giving five repetitions for each. The method of planting is illustrated below:

Row 1	Row 2	Row 3	Row 4	Row 5
Prog. 5—Plot 21	Prog. 4—Plot 16	Prog. 3—Plot 11	Prog. 2—Plot 6	Prog. 1—Plot 1
" 1— " 22	" 5 – " 17	" 4— " 12	" 3— " 7	" 2— " 2
" 2 " 23	" 1— " 18	" 5— " 13	" 4— " 8	" 3— " 3
" 3— " 24	" 2— " 19	" 1 – " 14	" 5— " 9	" 4— " 4
" 4— " 25	" 3— " 20	" 2— " 15	" 1— " 10	" 5— " 5

The average results are summarized as follows:

Progeny No.	No. of stools	No. of stalks	Total Weight	Av. stalks per ft.	Wgt. per ft.	Wgt. per stalk	Wgt. per stool	Tons per acre	Stalks per stool
1	40	207	648	4.14	13.0	3.00	16.2	56.5	5.14
2	31	157	420	3.14	8.4	2.62	13.5	36.5	5.06
3	35	189	539	3.78	10.8	2.86	15.7	47.0	5.40
4	39	168	507	3.36	10.1	2.98	13.0	44.1	4.31
5	36	177	538	3.54	10.8	3.02	15.6	46.8	4.89
Total av.	181	898	2652	3.59	10.6	2.95	14.6	46.2	4.96

From the above general summary we see that progeny 1 is distinctly better than any other. The weight of cane per foot is greater, it has more stalks per foot and the stalks weigh more. Of the other progenies, 3 and 5 are about equal, while Progeny 2 is very much inferior.

In Fig. 1 we have attempted to show these differences in a graphic way. Progeny 1 was planted in plots 1, 10, 14, 18 and 22. If we compare the yields from these plots we find that they are always greater than the yields from any adjoining plot. That is, plot 1 produced more cane than either 2 or 6, plot 10 was better than either 5, 9 or 15; plot 14 was better than 9, 13, 15 or 19, and so on.

Results of this nature prove conclusively that in this case progeny 1 is superior to any other in this lot. It now remains to prove whether this superior progeny will continue being superior or will it go back.

The results in regard to the poor Progeny, No. 2, are almost as conclusive. Progeny 2 was in plots 2, 6, 15, 19 and 23. The yields from progeny 2 are always less than that of any of the adjoining plots except in two cases. Plot 24 is poorer than 23, and plot 11 is poorer than 6; in all other cases Progeny 2 was poorer.

If we were doing this work on a plantation we would select progeny 1 for further work. All the others would be discarded, except that we would plant some few seed of Progeny 2 in our progeny areas for purposes of comparison to see if this progeny remains poor, improves or possibly goes back entirely.

In this case we are keeping one progeny out of five on the second selection. We believe this to be a fair figure. Twenty to thirty per cent seems to be about how it works out.

All the good seed from Progeny 1 should be planted. Seed from the best stools for further progeny work and the other seed should be planted by itself for plantation seed later, because, if Progeny 1 remains good, this will furnish seed superior to the general run of plantation seed and at no extra cost.

Progenies 3 and 5 are as good or better than plantation run, so all good seed from these could be used for plantation planting. In no case should seed from Progeny 2 be used for plantation planting as that would be spreading what is evidently a very inferior strain.

Progeny 5

In selecting stools from Progeny 1 for progeny planting we proceed as follows: We note that the average weight per stool was 16.2 pounds and the average weight per stalk 3.00 pounds, and that there were 5.14 stalks per stool. Stools which are to be selected for progeny planting should equal or surpass this average. This standard may be varied to suit conditions, such as size of area available for progeny planting. We do not believe this selection within the progeny to be nearly so important as the selection of the progeny itself, and the total discarding of the poor ones. No matter how high the stool standard is set within each progeny there

is no loss as all the remaining seed (of the good progenies) goes for plantation or mother field planting.

In the detailed data given at the end of this article we indicate the stools which were selected and planted. In some cases you will note we lowered the standard in weight of stalk or number of stalks per stool when some other item was very high. Stool 1-10 consisted of four stalks only, but the stalks weighed 4.8 pounds each, so that stool was taken. Stool 1-18 had stalks weighing only 2.69 pounds each but this stool had 9 stalks with a total weight of 24¼ pounds. In selecting, the primary factor to consider, of course, is the comparative weight of cane per foot of row, the other factors being of secondary importance and should be regarded as such.

In progeny planting, when several stools are selected, the seed of each is planted together and separated from the seed of the next stool by means of a stake or by planting one or two seeds of another variety of cane.

In our progeny planting at Waipio and at Makiki we use so-called Cuban-seed, that is, a 3-eye cutting from which the two end eyes are gouged out. At Waipio we plant one eye per running foot. In Honolulu, where we expect to make a closer stool study, we space the eyes two feet apart. In every line we plant two or three extra eyes in order to have material of the same kind to replant any misses. After germination is completed, any of these extra seed not used for replanting are dug up and discarded.

After trying a number of systems we have concluded that numbering the progenies should be made as simple as possible. A method which we favor is as follows: In the first stool selection, the selected stools are to be given temporary numbers, and called stool 1, stool 2, etc. They are not to be given progeny numbers until after the first selection. If a plantation selects 1,000 stools they are numbered 1 to 1,000. Then, if at the first selection 200 of these stools are kept for further study, these selected stools are given progeny numbers 1 to 200, or if the plantation already has progenies, the new ones are numbered consecutively from the last numbered progeny. Proper notes are made in the records to show from which stool the progeny originated. From then on no changes are made in the progeny numbers.

At the next selection, if stool selections are made within the progeny and planted as units the stool number is added to the progeny number. If the first stool in Progeny 10 is selected it is numbered 10-1, the fifth stool would be 10-5, etc. All "mass" plantings of Progeny 10 would continue to be known simply as Progeny 10. In the fourth selection if 10-1 is taken and again separated into stool planting we add the stool number as before; if the second and sixth stools are taken the numbers would be 10-1-2, and 10-1-6. All mass planting would again be simply Progeny 10.

We have discontinued the "snake fashion" planting as we find that it offers certain inconveniences when the weighing method is used. In irrigated fields we plant full lines of each progeny. In case there is not enough seed we finish the line with another variety and start the next progeny on a new line.

Progeny Planting at Makiki Plots

We shall now briefly describe our handling of the above five Makiki progenies for further study.

Progeny 1 was selected as the best.

We selected what we considered the 18 best stools. These were numbered 1-1 to 1-18. Progeny 3 was very uniform and possibly the next best. We selected the 10 best stools from this.

Progeny 2 was markedly the poorest progeny, so we determined to carry this along as a poor progeny for purposes of comparison. In order to illustrate, if possible, the effect of selection downward as well as upward, we selected for planting only the poorest stools in Progeny 2. So we now have for comparison the best stools and seed from the best progenies and the poorest stools and seed from the poorest progeny.

In all cases we used a 3-eye seed piece with two eyes cut out, and spaced the eyes 2 feet in a 30-foot line. In each line we planted 3 extra eyes from the same stool if possible, in order to be able to replant any misses.

The plan of the planting is given below:

Test 3. Section 2. Seed from Section 11, Test 2. Planted June, 1923.

Row	Makiki Progeny.				
1	3-10	(15)	3	extra	
2	1-18	(15)	2	"	
3	3-9	(14)	4	"	from stool 3-10
4	1-17	(15)	3	"	
5	3-8	(15)	2	"	
6	1-16	(15)	2	"	
7	2-12	(15)	3	"	
8	1-15	(15)	1	"	
9	3-7	(15)	2	"	
10	1-14	(15)	1	"	
11	2-10	(6)			2-11 (6) 3 extra not from same stool
12	1-13	(15)	3	"	
13	3-6	(15)	3	"	
14	1-12	(15)	3	"	
15	2-9	(13)	6	"	not from same stool
16	1-11	(15)	3	"	
17	3-5	(15)	3	"	
18	1-10	(15)	3	"	from stool 1-11
19	2-7	(10)			2-8 (5) 3 extra
20	1-9	(15)	3	"	
21	3-4	(12)	6	"	not from same stool
22	1-8	(15)	3	"	
23	2-5	(10)			2-6 (5) 3 extra
24	1-7	(15)	3	"	
25	3-3	(15)	3	"	
26	1-6	(15)	3	"	
27	2-3	(8)	2	"	2-4 (3) 5 extra not from same stool.
28	1-5	(15)	3	"	
29	3-2	(15)	3	"	
30	1-4	(15)	2	"	
31	2-2	(15)	3	"	
32	1-3	(15)	1	"	
33	3-1	(15)	3	"	
34	1-2	(15)	3	"	
35	2-1	(15)	3	"	
36	1-1	(15)	3	"	
	crop				

In the above outline the figure 1-1 in line 1 indicates the first stool in Progeny 1. This is the legend placed on the stake. The other figures are not to be on the

stake, but on the map only. The (15) shows 15 eyes spaced 2 feet apart in the 30-foot row. Three extra seeds from this same stool were planted for replacement in case some of the 15 should not come up. As soon as germination is complete all "extras" not needed are to be dug up. In this way we are to have no misses, and the replacements are to be from the same material. In some cases, as in line 11, there was not enough seed from 1 stool to plant a line, in which case 2 stools were used.

We would suggest that small tests of this nature be laid out on the plantations which are doing seed selection work. A small area only is needed. In the above layout we used 36 lines 30 feet long.

By such a procedure we would soon have very valuable information as to actual value of bud selection work. Such tests would be extremely interesting to all in indicating the extremes possible. The good progenies would indicate the possible gains to be expected and the poor progenies would show what is likely to happen when such material is planted.

10 ft. Row No..	Row No.........	Progeny No.....	Stool No.........	No. of Stalks...	Wgt. per Stool..	Aver. Stalks per Foot......	Wgt. per Foot....	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre...	Remarks
1	36	4	1	4	11.2	..	....	2.4	...	...	
..	..	..	2	5	7.8	..	....	1.6	...	...	
..	..	..	3	4	11.5	..	....	2.9	...	...	
..	..	..	4	2	10.7	..	....	5.3	...	...	
..	..	..	5	3	14.9	..	....	5.0	...	...	
..	..	..	6	7	15.1	..	....	2.2	...	...	
..	..	..	7	4	11.4	..	....	2.9	...	...	
..	..	..	8	6	19.4	..	....	3.2	...	...	
Average				35	102.0	3.5	10.2	2.9	12.8	44.4	
1	37	3	1	8	26.7	..	....	3.3	...	...	3–2 Planted
..	..	..	2	4	11.6	..	....	2.9	...	...	
..	..	..	3	3	6.2	..	....	2.1	...	...	
..	..	..	4	4	15.1	..	....	3.8	...	...	
..	..	..	5	5	11.1	..	....	2.2	...	...	
..	..	..	6	6	17.2	..	....	2.9	...	...	
..	..	..	7	13	28.4	..	....	2.2	...	...	3–1 Planted
Average				43	116.1	4.3	11.6	2.7	18.0	50.5	
1	38	2	1	6	18.6	..	....	3.1	...	...	
..	..	..	2	4	13.2	..	....	3.3	...	...	
..	..	..	3	7	20.1	..	....	2.3	...	...	
..	..	..	4	5	15.0	..	....	3.0	...	...	
..	..	..	5	6	13.2	..	....	2.2	...	...	
..	..	..	6	13	40.9	..	....	3.1	...	...	
Average				41	121.0	4.1	12.1	3.0	20.3	52.7	
1	40	5	1	10	31.5	..	....	3.2	...	...	
..	..	..	2	5	14.9	..	....	2.4	...	...	
..	..	..	3	7	32.7	..	....	4.7	...	...	
..	..	..	4	5	15.3	..	....	3.1	...	...	
..	..	..	5	7	25.5	..	....	3.6	...	...	
..	..	..	6	10	32.6	..	....	3.3	...	...	
..	..	..	7	4	3.2	..	....	.8	...	...	
Average				48	155.7	4.8	15.6	3.2	22.2	67.5	

10 ft. Row No..	Row No..........	Progeny No.....	Stool No.........	No. of Stalks...	Wgt. per Stool..	Aver. Stalks per Foot......	Wgt. per Foot..	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre..	Remarks
1	39	1	1	6	21.2	..	....	3.5	...	...	1–6 Planted
..	..	..	2	8	26.4	..	....	3.3	...	...	1–5 Planted
..	..	..	3	4	16.5	..	....	4.1	...	...	1–4 Planted
..	..	..	4	4	11.6	..	....	2.9	...	...	
..	..	..	5	6	26.5	..	....	4.4	...	...	1–3 Planted
..	..	..	6	7	20.9	..	....	3.0	...	...	1–2 Planted
..	..	..	7	7	29.1	..	....	4.2	...	...	1–1 Planted
..	..	..	8	7	20.6	..	....	2.9	...	...	
Average				49	172.8	4.9	17.3	3.5	21.6	75.3	
2	36	3	1	2	1.4	..	....	0.7	...	...	
..	..	..	2	3	5.5	..	....	1.8	...	...	
..	..	..	3	4	15.9	..	....	4.0	...	...	
..	..	..	4	5	17.1	..	....	3.4	...	...	3–4 Planted
..	..	..	5	7	23.2	..	....	3.3	...	...	3–3 Planted
..	..	..	6	4	15.5	..	....	3.9	...	...	
..	..	..	7	5	12.1	..	....	2.4	...	...	
Average				30	90.7	3.0	9.1	3.0	12.9	42.3	
2	37	2	1	1	.4	..	....	.4	...	...	2–4 Planted
..	..	..	2	5	10.9	..	....	2.2	...	...	2–3 Planted
..	..	..	3	6	18.9	..	....	3.2	...	...	2–2 Planted
..	..	..	4	5	11.0	..	....	2.2	...	...	2–1 Planted
Average				17	41.2	1.7	4.12	2.4	10.3	17.8	

10 ft. Row No..	Row No..........	Progeny No.....	Stool No.........	No. of Stalks...	Wgt. per Stool..	Aver. Stalks per Foot......	Wgt. per Foot...	Wgt. per Stalk...	Wgt. per Stool..	Tons per Acre...	Remarks
2	38	1	1	5	18.0	..	....	3.6	...	...	1–12 Planted
..	..	..	2	6	21.4	..	....	3.6	...	...	1–11 Planted
..	..	..	3	4	19.2	..	....	4.8	...	...	1–10 Planted
..	..	..	4	6	22.0	..	....	3.7	...	...	1–9 Planted
..	..	..	5	5	18.5	..	....	3.7	...	...	1–8 Planted
..	..	..	6	7	22.0	..	....	3.1	...	...	1–7 Planted
..	..	..	7	3	5.0	..	....	1.7	...	...	
..	..	..	8	3	10.4	..	....	3.5	...	...	
Average				39	136.5	3.9	13.65	3.2	17.1	59.5	
2	39	5	1	5	15.8	..	....	3.2	...	...	
..	..	..	2	5	16.1	..	....	3.2	...	...	
..	..	..	3	6	13.9	..	....	2.3	...	...	
..	.	..	4	6	18.9	..	....	3.1	...	...	
..	..	..	5	5	14.7	..	....	2.9	...	...	
..	..	..	6	3	11.0	..	....	3.7	...	...	
..	..	..	7	5	17.0	..	....	3.4	...	...	
Average				35	107.4	3.5	10.74	3.07	15.3	46.8	
2	40	4	1	6	18.4	..	....	3.1	...	...	
..	..	..	2	5	13.6	..	....	2.7	...	...	
..	..	..	3	5	16.0	..	....	3.2	...	...	
..	..	..	4	6	16.0	..	....	2.7	...	...	
..	..	..	5	7	25.7	..	....	3.7	...	...	
..	..	..	6	4	15.8	..	....	3.9	...	...	
..	..	..	7	3	10.3	..	....	3.4	...	...	
..	..	..	8	4	17.2	..	...	4.3	...	...	
Average				39	133.0	3.9	13.3	3.41	16.6	57.9	

10 ft. Row No..	Row No........	Progeny No.....	Stool No........	No. of Stalks...	Wgt. per Stool..	Aver. Stalks per Foot.....	Wgt. per Foot..	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre..	Remarks
3	36	2	1	4	6.0	..	....	1.5	...	...	2–5 Planted
..	..	..	2	4	6.5	..	....	1.62	...	...	2–6 Planted
..	..	..	3	3	9.5	..	....	3.19	...	...	
..	..	..	4	4	13.25	..	....	3.31	...	...	
..	..	..	5	5	16.0	..	....	3.20	...	...	
..	..	..	6	7	14.25	..	....	2.03	...	...	
Average			4.5	27	65.5	2.7	65.5	2.43	10.9	28.3	
3	37	1	1	7	20.75	..	....	2.96	...	...	1–17 Planted
..	..	..	2	4	9.75	..	....	2.44	...	...	
..	..	..	3	2	4.25	..	....	2.12	...	...	
..	..	..	4	4	9.75	..	....	2.44	...	...	
..	..	..	5	5	18.5	..	....	3.70	...	...	1–16 Planted
..	..	..	6	5	19.8	..	....	3.96	...	...	1–15 Planted
..	..	..	7	4	18.0	..	....	4.50	...	...	1–14 Planted
..	..	..	8	8	28.25	..	....	3.53	...	...	1–13 Planted
Average			4.86	39	129.1	3.9	12.9	3.05	16.1	56.2	
3	38	5	1	6	18.25	..	....	3.04	...	...	
..	..	..	2	8	17.00	..	....	2.13	...	...	
..	..	..	3	5	18.00	..	....	3.60	...	...	
..	..	..	4	5	10.75	..	....	2.05	...	...	
..	..	..	5	3	6.75	..	....	2.25	...	...	
..	..	..	6	8	24.00	..	....	3.00	...	...	
..	..	..	7	6	23.75	..	....	3.96	...	...	
Average			5.87	41	118.0	4.1	11.8	2.88	19.7	51.4	

10 ft. Row No..	Row No........	Progeny No.....	Stool No........	No. of Stalks...	Wgt. per Stool..	Aver. Stalks per Foot.....	Wgt. per Foot...	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre..	Remarks
3	40	3	1	8	20.0	..	....	2.50	...	...	
..	..	..	2	5	15.75	..	....	3.15	...	...	
..	..	..	3	2	5.5	..	....	2.75	...	..	
..	..	..	4	4	11.8	..	....	2.95	...	..	
..	..	..	5	7	19.75	..	....	2.82	...	...	3–6 Planted
..	..	..	6	8	22.0	..	....	2.75	...	...	3–5 Planted
..	..	..	7	5	11.0	..	....	2.20	...	...	
Average			5.57	39	105.8	3.9	10.58	2.72	15.1	46.0	
3	39	4	1	3	6.75	..	....	2.25	...	...	
..	..	..	2	5	14.25	..	....	2.85	...	...	
..	..	..	3	4	16.50	..	....	4.12	...	...	
..	..	..	4	5	17.00	..	....	3.40	...	...	
..	..	..	5	6	17.50	..	....	2.92	...	...	
..	..	..	6	5	17.00	..	....	3.40	...	...	
..	..	..	7	4	12.25	..	....	3.06	...	...	
..	..	..	8	4	14.00	..	....	3.50	...	...	
Average			4.5	36	115.25	3.6	11.5	3.20	14.40	50.1	

10 ft. Row No..	Row No.........	Progeny No.....	Stool No........	No. of Stalks...	Wgt. per Stool..	Aver. Stalks per Foot......	Wgt. per Foot...	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre...	Remarks
4	36	1	1	4	8.00	..	....	2.00	...	...	
..	..	..	2	4	11.00	..	....	2.75	...	...	
..	..	..	3	3	8.50	..	....	2.83	...	...	
..	..	..	4	3	7.75	..	....	2.58	...	...	
..	..	..	5	5	11.75	..	....	2.35	...	...	
..	..	..	6	5	14.00	..	....	2.80	...	...	
..	..	..	7	4	12.80	..	....	3.20	...	...	
..	..	..	8	4	10.80	..	....	2.70	...	...	
Average				32	84.60	3.2	8.46	2.64	10.6	36.8	
4	37	5	1	4	10.8	..	....	2.70	...	...	
..	..	..	2	3	8.25	..	....	2.75	...	...	
..	..	..	3	4	10.8	..	....	2.70	...	...	
..	..	..	4	4	7.75	..	....	1.94	...	...	
..	..	..	5	6	19.25	..	....	3.21	...	...	
..	..	..	6	4	13.00	..	....	3.25	...	...	
..	..	..	7	1	2.75	..	....	2.75	...	...	
Average				26	72.6	2.6	7.26	2.79	10.4	31.6	
4	38	4	1	5	11.75	..	....	2.35	...	...	
..	..	..	2	6	17.75	..	....	2.96	...	...	
..	..	..	3	3	9.75	..	....	3.28	...	...	
..	..	..	4	5	19.00	..	....	3.80	...	...	
..	..	..	5	7	21.00	..	....	3.00	...	...	
..	..	..	6	2	4.00	..	....	2.00	...	...	
..	..	..	..	4	7.8	..	....	1.95	...	...	
Average				32	91.05	3.2	9.11	2.84	13.0	39.6	
4	39	3	1	5	15.25	..	....	3.05	...	...	
..	..	..	2	6	19.80	..	....	3.30	...	...	3–9 Planted
..	..	..	3	6	16.25	..	....	2.71	...	...	
..	..	..	4	4	12.70	..	....	3.17	...	...	
..	..	..	5	6	19.80	..	....	3.30	...	...	3–8 Planted
..	..	..	6	5	18.25	..	....	3.65	...	...	
..	..	..	7	7	20.80	..	....	2.97	...	...	3–7 Planted
Average				39	122.85	3.9	12.29	3.15	17.55	53.5	
4	40	2	1	4	8.00	..	....	2.00	...	...	2–8 Planted
..	..	..	2	7	23.25	..	....	3.32	...	...	
..	..	..	3	6	19.8	..	....	3.30	...	...	
..	..	..	4	4	9.0	..	....	2.25	...	...	2–7 Planted
..	..	..	5	4	16.8	..	....	4.20	...	...	
..	..	..	6	8	24.8	..	....	3.10	...	...	
..	..	..	7	5	17.25	..	....	3.45	...	...	
Average				38	118.9	3.8	11.89	3.13	16.98	51.8	
5	36	5	1	3	9.75	..	....	3.25	...	...	
..	..	..	2	4	12.75	..	....	3.19	...	...	
..	..	..	3	2	7.0	..	....	3.50	...	...	
..	..	..	4	3	10.75	..	....	3.58	...	...	
..	..	..	5	3	12.8	..	....	4.27	...	...	
..	..	..	6	2	5.75	..	....	2.87	...	...	
..	..	..	7	2	6.75	..	....	3.37	...	...	
..	..	..	8	8	18.8	..	....	2.35	...	...	
Average				27	84.35	2.7	8.44	3.12	10.50	36.6	

10 ft. Row No..	Row No........	Progeny No.....	Stool No........	No. of Stalks....	Wgt. per Stool..	Aver. Stalks per Foot......	Wgt. per Foot...	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre...	Remarks
5	37	4	1	4	8.8	..	....	2.20	...	...	
..	..	..	2	5	10.75	..	....	2.15	...	...	
..	..	..	3	3	10.8	..	....	3.60	...	...	
..	..	..	4	2	3.75	..	....	1.87	...	...	
..	..	..	5	3	10.25	..	....	3.42	...	...	
..	..	..	6	3	7.8	..	....	2.60	...	...	
..	..	..	7	3	5.8	..	....	1.93	...	...	
..	..	..	8	3	8.0	..	....	2.67	...	...	
Average				26	65.96	2.6	6.60	2.53	8.26	28.7	
5	38	3	1	5	17.8	..	....	3.56	...	...	3–10 Planted
..	..	..	2	8	19.0	..	....	2.38	...	...	
..	..	..	3	4	9.75	..	....	2.44	...	...	
..	..	..	4	7	16.75	..	....	2.40	...	...	
..	..	..	5	5	17.25	..	....	3.45	...	...	
..	..	..	6	3	9.0	..	....	3.00	...	...	
..	..	..	7	6	13.75	..	....	2.64	...	...	
Average				38	103.30	3.80	10.83	2.73	14.71	42.8	
5	39	2	1	6	13.25	..	....	2.21	...	...	
..	..	..	2	4	10.25	..	....	2.57	...	...	
..	..	..	3	6	10.0	..	....	1.67	...	...	2–12 Planted
..	..	..	4	4	8.25	..	....	2.06	...	...	2–11 Planted
..	..	..	5	2	4.8	..	....	2.40	...	...	2–10 Planted
..	..	..	6	2	2.0	..	....	1.00	...	...	2–9 Planted
..	..	..	7	5	11.25	..	....	2.25	...	...	
..	..	..	8	5	13.0	..	....	2.60	...	...	
Average				34	72.8	3.40	7.28	2.14	9.10	31.8	
5	40	1	1	5	14.8	..	....	2.96	...	...	
..	..	..	2	6	15.75	..	....	2.63	...	...	
..	..	..	3	7	16.8	..	....	2.40	...	...	
..	..	..	4	6	13.8	..	....	2.30	...	...	
..	..	..	5	5	11.75	..	....	2.35	...	...	
..	..	..	6	9	24.25	..	....	2.69	...	...	1–18 Planted
..	..	..	7	5	14.0	..	....	2.80	...	...	
..	..	..	8	5	14.0	..	....	2.80	...	...	
Average				48	125.15	4.8	12.51	2.61	15.66	54.5	

SUMMARY

Row No..........	Progeny No.....	No. of Stools...	No. of Stalks...	Total Weight...	Aver. Stalks per Foot......	Wgt. per Foot...	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre...	Remarks
39	1	8	49	172.8	4.9	17.30	3.50	21.6	75.3	
38	1	8	39	136.5	3.9	13.60	3.20	17.1	59.5	
37	1	8	39	129.1	3.9	12.90	3.05	16.1	56.2	
36	1	8	32	84.6	3.2	8.46	2.64	10.6	36.8	
40	1	8	48	125.1	4.8	12.51	2.61	15.7	54.5	
Average		40	207	648.1	4.14	12.95	3.00	16.20	56.5	
38	2	6	41	121.6	4.1	12.10	3.00	20.3	52.7	
37	2	4	17	41.2	1.7	4.12	2.40	10.3	17.8	
36	2	6	27	65.5	2.7	6.55	2.43	10.9	28.3	
40	2	7	38	118.9	3.8	11.89	3.13	17.0	51.8	
39	2	8	34	72.8	3.4	7.28	2.14	9.1	31.8	
Average		31	157	420.0	3.14	8.39	2.62	13.5	36.5	
37	3	7	43	116.1	4.3	11.60	2.70	18.0	50.5	
36	3	7	30	90.7	3.0	9.10	3.00	12.9	42.3	
40	3	7	39	105.8	3.9	10.58	2.72	15.1	46.0	
39	3	7	39	122.9	3.9	12.29	3.15	17.6	53.5	
38	3	7	38	103.3	3.8	10.83	2.73	14.7	42.8	
Average		35	189	538.8	3.78	10.78	2.86	15.71	47.0	
36	4	8	35	102.0	3.5	10.2	2.90	12.8	44.4	
40	4	8	39	133.0	3.9	13.3	3.41	16.6	57.9	
39	4	8	36	115.3	3.6	11.5	3.20	14.4	50.1	
38	4	7	32	91.1	3.2	9.1	2.84	13.0	39.6	
37	4	8	26	66.0	2.6	6.6	2.53	8.3	28.7	
Average		39	168	507.4	3.36	10.10	2.98	13.02	44.1	
40	5	7	48	155.7	4.8	15.6	3.20	22.2	67.5	
39	5	7	35	107.4	3.5	10.7	3.10	15.3	46.8	
38	5	7	41	118.0	4.1	11.8	2.88	19.7	51.4	
37	5	7	26	72.6	2.6	7.3	2.79	10.4	31.6	
36	5	8	27	84.4	2.7	8.4	3.12	10.5	36.6	
Average		36	177	538.1	3.54	10.76	3.02	15.62	46.8	

FINAL SUMMARY

	Progeny No.....	No. of Stools...	No. of Stalks...	Total Weight...	Aver. Stalks per Foot......	Wgt. per Foot...	Wgt. per Stalk..	Wgt. per Stool..	Tons per Acre...	Remarks Stalks per Stool
	1	40	207	648.1	4.14	12.95	3.00	16.20	56.5	5.14
	2	31	157	420.0	3.14	8.39	2.62	13.50	36.5	5.06
	3	35	189	538.8	3.78	10.78	2.86	15.71	47.0	5.40
	4	39	168	507.4	3.36	10.10	2.98	13.02	44.1	4.31
	5	36	177	538.1	3.54	10.76	3.02	15.62	46.8	4.89
Average					3.59	10.63	2.88	14.84	46.2	

Forestry on Oahu*

Up to June 1st of the present year, there had been planted on Oahu, under Mr. McEldowney's direction, 186,814 trees. He would have planted a far greater number had additional trees of a suitable nature been available for planting during periods when the weather was favorable for carrying on this operation.

Fig. 1. *Ficus macrophylla* from seed sown in forest above Wahiawa in August, 1922. Photo March, 1923.

*From a report by Dr. Lyon, dated July 23, 1923.

In addition to planting out trees, a considerable amount of fig seed has been scattered by hand on stumps and logs in partially denuded sections of the forest. A great many sturdy seedlings have sprung up and established themselves as a result of this procedure (see Fig. 1). Large quantities of fig seed have also been sown from Army airplanes and we are justified in expecting favorable results from this operation.

In setting out tree seedlings, our idea has been to infect the forest with vigorous blood at as many points as possible. For many reasons, it has been advisable to make our first plantings at intervals along the lower border of the forest reserve. This is carrying out our general plan which contemplates the construction of a continuous barrier forest below the remaining native forest. When the trees in this barrier forest reach a fruiting stage, the seeds will be carried by natural agencies into the dead and dying forest above. At the same time, the trees will spread down the mountain slopes on to the waste lands below.

Fig. 2. *Ficus macrophylla* at Ewa Mill. Planted Feb., 1922. Photo taken June 4, 1923. Photo supplied by Mr. George F. Renton, Jr.

Before making each planting, we have obtained permission from the owners or lessees of the land to do the work, and have also received assurance that our plantings will receive the necessary protection. In most cases, we have obtained material aid from the parties interested in the land being planted. A continuous barrier forest planted under such conditions will establish the lower limit of the effective forest reserve regardless of the boundary set on the map, and will, at the same time, assure adequate protection for the reserve as a whole.

We have fostered the planting of trees on private grounds and about plantation camps. A very large number of trees have been supplied for this purpose to both sugar and pineapple companies. Then, we have induced various interests to plant windbreaks across open stretches and on the crests of gulches, while con-

siderable planting has been done on the waste lands on the slopes of gulches. If we can secure continued cooperation in this direction, the table land between the Koolau and Waianae mountains will eventually become dotted with groves of trees, while all of the gulches should be well forested. Our ultimate object is to build up a solid forest on the upper slopes of the Koolau mountains to cover all lands above the areas now cultivated and to have these forests continue down every gulch to the sea coast. In addition, the open areas between gulches will carry numerous groves. Under such conditions, the sweep of wind across the table land will be greatly impeded and this will materially affect the climate in this section of the island to the benefit of the crops grown thereon.

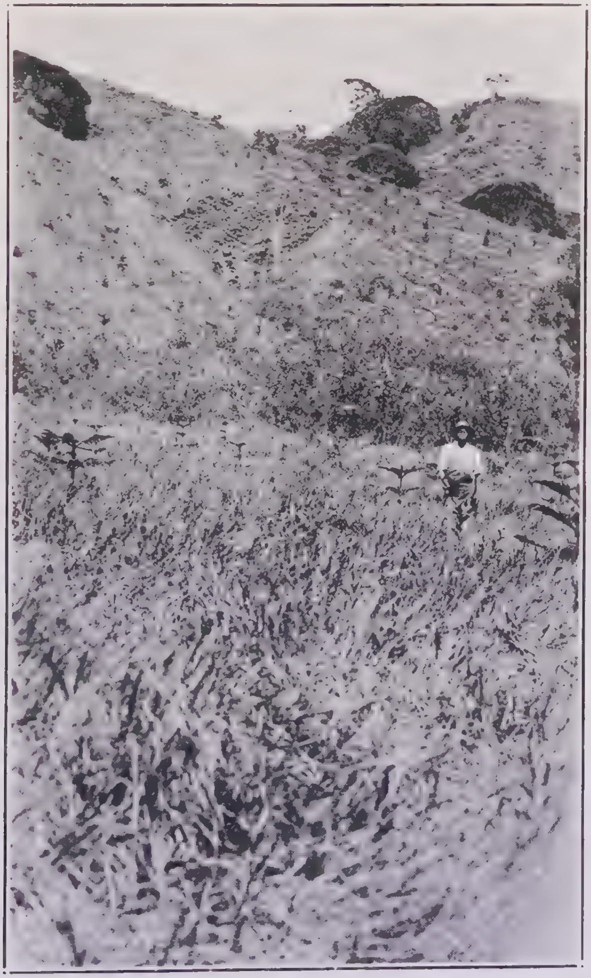


Fig. 3. *Araucaria excelsa*, Norfolk Island Pine, at Wahiawa.

Up to the present time, we have proceeded rather cautiously in the planting of new varieties of trees in order not to plant out a large number of some variety that could not succeed under the environment in which it was placed. Some spe-

cies that we expected to succeed have failed, while others considered very doubtful have shown great promise. We have quite a number of species which have proven their ability to grow under conditions prevailing on our watersheds and we can now proceed with planting operations on a large scale and with more confidence in the ultimate success of our work. Several species of trees long ago introduced but, until now, represented by only a few specimens in the islands, have proven of great merit when planted in our forests. The presence of old fruiting trees makes the rapid propagation of these species possible and we are growing large stocks of seedlings.

We are rapidly getting into the position where we know what to plant for best results and can procure an adequate supply of trees to enable us to make plantings of any size that available funds will permit.

Fig. 4. Forest Plantings at Wahiawa, age 20 months. *Enterolobium cyclocarpum, Dillenia indica, Melaleuca leucadendron, Rhus semialata,* and others.

Wahiawa Nursery

Through the assistance and cooperation of the Bureau of Agriculture and Forestry, the Wahiawa Water Company and the citizens of Wahiawa, we have secured the free use of some five acres of government land in Wahiawa for a forest nursery. The Wahiawa Water Company has laid a pipe line to this nursery and supplies us with free water. Mr. McEldowney is rapidly creating here a very efficient nursery in which we expect to grow a large number of trees for distribution on Oahu. We are also propagating at this nursery for distribution to other islands high land trees which do not thrive, even as seedlings, in the low land nurseries in Honolulu and Hilo.

Forest Reserves Should Be Defined and Extended

When we began our investigation of forest conditions on Oahu, it became evident at once that the first great need was a more exact demarkation of the existing forest reserves and the extension of these reserves to take in all effective watershed areas that could be spared from cultivation.

The slopes of the Koolau mountains from Moanalua to Kahuku gather most of the water entering the artesian basins of Pearl Harbor, Waialua and Kahuku as well as all of the water delivered into the Wahiawa Reservoir and the Koolau ditch. The very existence of the several plantations around Pearl Harbor and those at Waialua and Kahuku depends upon the maintenance of the water supply gathered by this small area of mountainous country, yet less than one-half of the effective watershed area is now marked off as forest reserves.

Cattle are still invading this area at several points and at the Kahuku end they penetrate far into the mountains which have been denuded of forest in most places through their ravages. The easterly end of this area has been set aside as the Ewa forest reserve but it has not been respected as a reserve, for it seems that the boundary is at all times subject to change without notice.

Fig. 5. Forest Plantings at Wahiawa, age 20 months. *Enterolobium cyclocarpum, Dillenia indica, Melaleuca leucadendron, Rhus semialata,* and others.

The delineation of existing forest reserves and the creation of new forest reserves are, of course, functions of the Bureau of Agriculture and Forestry. We are working in close cooperation with their officers, who fully recognize the necessity of enlarging and consolidating the forest reserves on the Koolau range.

Mr. Judd has given this matter much attention of late and has agreed to concentrate the energies of his staff on this project during the present summer. Unfortunately, the press of routine work has thus far prevented him from carrying

out his intentions, but he has just assured us that he will be on this job within a few days. We shall place all of our accumulated data at his disposal and assist him in every way possible in the field.

The ultimate goal towards which we shall strive is the creation of a permanent and well defined forest reserve including all of the effective watershed area on the Koolau mountains from Moanalua to Kahuku. Before this result can be accomplished, definite agreements must be made by the Territorial government with the owners and lessees of the various lands involved. We anticipate no serious opposition to the carrying out of this plan, but some financial settlement will probably be required by the interests now using certain portions of the proposed reserve as grazing lands.

The Forests on the Koolau Mountains Are Passing

The Koolau mountains were, at one time, covered with a heavy native forest which extended far down into the lands now devoted to pineapple culture. Years ago, the natural barrier forest was entirely destroyed and the interior forest exposed throughout the entire length of the mountain range. The native trees of

Fig. 6. *Dillenia indica* in forest planting at Wahiawa.

the inner forest, accustomed to protection, could not withstand this exposure and consequently the forest has continued to recede along its entire front. The inroads of woodchoppers and the invasion of stock opened, at many points, deep lanes into the forest. These constituted avenues for the entrance of two pestiferous plants of recent introduction, the Hilo grass and staghorn fern, which are keeping up a steady pressure on the forest, pushing back the native vegetation and preventing its rehabilitation. They quickly occupy every new opening that appears and from these vantage points invade the forest in every direction. The

native trees are quite unable to tolerate interference from man and stock or to repel the aggression of introduced plants. They quickly succumb before the forces turned against them. They possess no ability to recuperate. They regain no lost ground. Each tree that dies exposes its neighbors to added pressure from the natural forces destroying the forest. These forces are gathering momentum from year to year so that the destruction will proceed with ever-increasing rapidity.

The forest on this mountain range was, at one time, a dense rain forest that never dried out and consequently was never in danger of being consumed by fire. For many years now, the old trees have been dying off rapidly while no

Fig. 7. *Enterolobium cyclocarpum* after 20 months in the ground at Wahiawa.

young trees have sprung up to take their places. The result is that the once dense rain forest has become a semi-open forest which dries out quickly, and for a considerable period each year assumes a state where it would burn if once a fire got started. The constantly increasing number of dead trees adds to the fire peril.

Then the ever-present uluhi fern affords the ideal kindling material in which a fire can easily start and quickly spread. This fern builds a compact blanket of material often five and sometimes ten feet thick, closely investing the trunks of all large trees and overtopping all small trees, shrubs and ferns. Only a few days of dry weather are required to dry out this fern blanket to a point where it will burn rapidly. We must expect that, sooner or later, disastrous forest fires will occur on the Koolau mountains, not only consuming the fern blanket and killing all the living trees which it has surrounded, but spreading from this blanket deep into the native forest. Several serious fires have occurred during the past year. It does not require deep and lengthy study of the situation to see that conditions on the Koolau mountains are rapidly assuming a state where a few disastrous fires will lay bare a great part of the effective watershed area.

Water and Forests on Oahu

The water problem on Oahu is very rapidly approaching a crisis. The supply available to Honolulu is inadequate to the demands made upon it, and it is now quite evident that sooner or later the city will experience a real and prolonged water famine. Not one of the plantations on Oahu obtains a sufficient water supply to give its cane the optimum irrigation and any diminution of the present supply is bound to seriously curtail the sugar yield.

The maintenance of a continuous water supply on Oahu depends not so much upon a heavy annual rainfall as upon the conservation of the water that falls during the rainy periods for use during the intervening dry spells. Oahu has no lakes and her artificial reservoirs are of very small capacity in comparison to the amount of water required. When the island experiences heavy rains, the greater part of the water quickly runs off as floods into the ocean and is lost to us. If we ascertain the total amount of fresh water now used on Oahu during a year and then make a liberal estimate based on available data of the amount of water falling in an equal period on the watersheds supplying this water, we find that the difference between these two amounts is far too small for safety and allows for no floods or other wastage.

For a continuous water supply, we must depend upon the slow run-off from our natural watersheds, and the underground waters tapped by our artesian wells.

The amount of water which will be supplied during dry periods as run-off from our watersheds will depend upon the area of these watersheds and the nature of the vegetation covering them. If the vegetation is such that it offers little obstruction to the flow of water, the run off will be rapid and our surface streams will be dry a few days after each heavy rain, but if the vegetation is such as to hold back the water, its delivery as run-off will be greatly prolonged.

The amount of water available in our artesian basins under a given rainfall will depend upon what proportion of this rainfall finds its way into the channels on our watersheds that lead into these artesian basins. If our watersheds were quite bare, permitting rapid run-off, a certain amount of water would still soak into the earth and thus enter the artesian basins, but anything that would impede the run-off would obviously increase the seepage into subterranean channels and thus increase the amount of water entering the artesian basins. It is a well recog-

nized fact that the nature of the vegetation on a watershed determines the water conserving capacity of that watershed in so far as surface run-off is concerned, but in the case of the watersheds on Oahu, it is obvious that their capacity for delivering water into the artesian basins is determined to even a greater degree, by the nature of the vegetation which covers them. In our economy, the delivery of water into our ar esian basins is of more importance than the delivery of water into our streams and reservoirs.

Fig. 8. *Tectona grandis,* teak-wood, in forest planting at Wahiawa.

The water supply on Oahu is drawn from a few small watersheds. These watersheds have been abandoned to the vagaries of men and the inroads of stock until now, their efficiency as water conserving agencies is greatly reduced. Uncontrolled natural forces have been set in motion which will eventually eliminate the native vegetation from these watersheds and render them barren hillsides with little or no water-conserving power.

The depletion of the forest on these watersheds has already gone so far that most of our surface streams are now dry the greater part of each year and there must be a corresponding decrease in the amount of water conserved by these watersheds for delivery into the artesian basins. We may dig new wells and new ditches but these will be of no avail to us in the long run for we cannot take out more water from underground sources than enters these sources by way of our watersheds.

Fig. 9. *Agathis robusta,* Kauri pine. Seedling was 10 inches tall when planted at Wahiawa in July, 1921. Photo taken in March, 1923.

It is a recognized fact that we are now overdrawing our artesian supply, but few people seem to realize that we are at the same time allowing the source of this supply to deteriorate. The candle is burning at both ends and we only fan the flames. Instead of spending our money to take more water out from the underground sources, we should spend this money to get more water into these

sources: in other words, cover our watersheds with a healthy, water-conserving forest.

Fresh water is a controlling factor in the development of Oahu. We have pushed that development almost, if not quite, to the limit under the water supply now available. The demands on this water supply are bound to increase, while the supply itself is decreasing and must continue to decrease for years to come, despite our best efforts to sustain it.

As fresh water is so vital to the life and industry of Oahu and, since our supply of this commodity depends so entirely upon the preservation of a few small watersheds in their highest efficiency, it is difficult to understand why popular sentiment does not demand that the government condemn the lands on these watersheds and consecrate them to the only service which they are capable of performing—that of water conservation. Continued neglect of these watersheds is suicidal, for everything fails with the failure of our water supply.

Recapitulation

From the standpoint of the sugar industry, we may analyze the water and forest situation as follows:

Not one of the sugar plantations on Oahu obtains a sufficient water supply to give its cane optimum irrigation.

Most of the water available to these plantations is derived from a comparatively small area on the Koolau mountains.

The efficiency of this area as a gatherer of water depends, to a very large extent, upon the nature of the forest covering it. This forest is rapidly deteriorating and will disappear in the course of a few years.

The watershed in question is not at the present time fulfilling the demands made upon it and its ability to fulfill these demands will decrease from year to year as its forest cover disappears.

We cannot continue to take out more water from our artesian basins than enters these basins. The only way to insure an increased supply is to insure that more water goes into these artesian basins. This water can enter only by way of our watersheds and a suitable forest cover is essential to hold back the flood waters until they enter underground channels instead of running off on the surface.

We may summarize the forestry work already accomplished on Oahu by the Experiment Station as follows:

A careful reconnaissance has been made of the watersheds on Oahu and a fair idea obtained of the condition and extent of the native forests and the size and location of areas which should be planted.

Experimental plantings, including a great many species of trees, have been made at intervals from Moanalua to Kahuku on the Koolau range and at several points on the Waianae range. These have given us valuable data regarding the most suitable trees to plant.

Seeds of the Moreton Bay fig have been sown by hand on stumps and logs in the forest. Many sturdy seedlings have sprung up and established themselves as

a result, thoroughly demonstrating the efficacy of this method of reforestation in partially denuded areas.

Nursery facilities have been secured and improved, enabling us to turn out tree seedlings to meet any and all demands.

Fig. 10. *Ficus glomerata.* Seedling was 15 in. in height when planted in forest land, Helemano, August, 1922. Photo March, 1923.

An adequate supply of seed of suitable trees has been assured.

We would outline a constructive forestry policy for Oahu as follows:

All effective watershed areas to be procured and set aside as forest reserves.

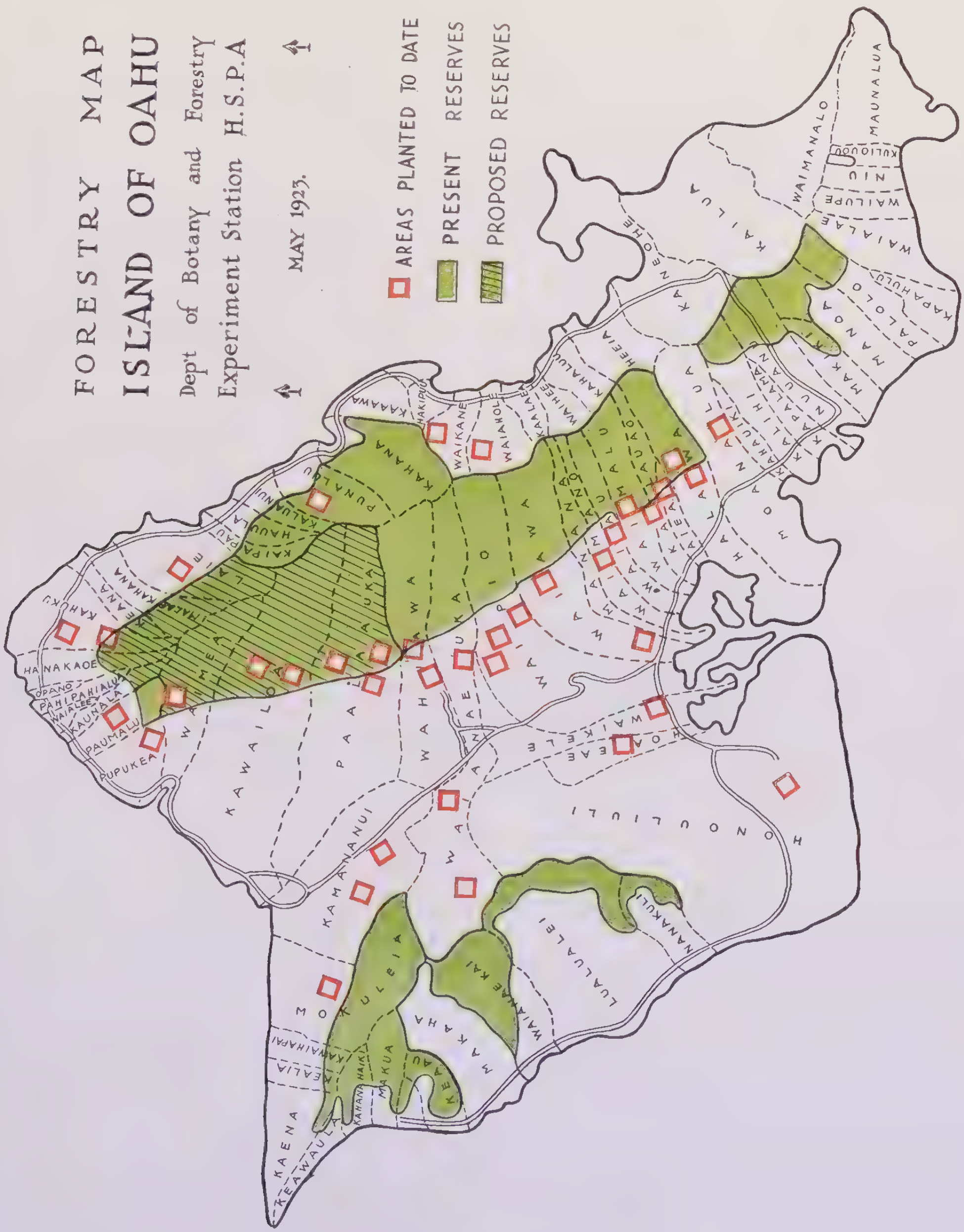
All forest reserves to be clearly defined in the field and adequately protected from injury by man, stock and fire.

Continuous barrier forests of appropriate trees to be planted within the boundaries of the reserves as rapidly as possible.

Plantings of suitable trees to be made at intervals in all denuded areas within the reserves.

Seeds of selected species of *Ficus* to be sown by hand and from airplanes throughout all declining forests.

A report prepared by Mr. Geo. A. McEldowney on the lands lying on the slopes of the Koolau mountains, which are, or should be, included in one forest reserve, follows. The status map and photographs illustrating the progress of the Oahu project are also contributed by him.



MOANALUA

Owned by Mr. S. M. Damon (Bishop Trust Company, agent).

While not in the Ewa Forest Reserve, it is adjacent to it and a portion of it should be included in this Reserve.

Fig. 11 *Platymiscium stipulare* in Helemano. Planted August, 1922. Photo March, 1923.

The area of this section is approximately 8,432 acres. It is a rather flat valley compared with valleys found in other sections of this Reserve. The lands above the continuation of the present Forest Reserve boundary are lower and more rolling; the sides of the gulches are very steep. It is well adapted for grazing and has been used as such for a number of years. With the exception of a few small fenced areas, the cattle have the run of the entire valley. There are a number of well built stock fences, some extending across the entire valley, but the gates are not closed, no attempts being made to confine the stock. At present there are between four and five hundred head of cattle and sixty head of horses using this range. This number will be gradually increased during the coming year, as the Damon interests are giving up their Koko Head lands and will concentrate their stock in Moanalua. In this valley there are also numerous large bands of wild hogs which are protected for hunting and have the run of the whole valley. They do a lot of damage to the undergrowth in some places; their depredations look like a cultivated field. There are also not less than twenty head of small

deer at large in this valley and they are doing considerable damage in the lower lands. The Hawaiian Pineapple Company has taken over and planted 396 acres of this land. The wild hogs did such damage to their plantings that they had to construct four miles of hog-tight fence to protect their fields.

The forests in this valley show the result of continual grazing. There are no heavy stands except in places which are inaccessible to stock. Those who have lived in this vicinity for years say that the valley stream has greater flood in the winter months, increasing in severity from year to year and dries up earlier in the summer than it did in former years, and conditions along the stream bed verify these statements.

No effort has been made in recent years to protect or increase the forest cover except a small area in the vicinity of Henry Damon's mountain house, which has been fenced and made a private Forest Reserve and a number of eucalyptus trees have been planted. In former years, prior to 1914, I believe some effort towards forest conservation was made such as the constructing of stock-tight barriers and the protecting of certain areas which were set aside as a sort of private forest reserve along the same lines as the present Government Reserve adjacent thereto. At the extreme upper portion of the valley, about four miles from the entrance, there is a water reserve and reservoir site. At this point there is a good fence across the entire valley that should be made stock-proof so as to preserve at least a portion of the valley.

A classification of these lands follows:

Cane land	1,468 acres
Pasture	3,436 acres
Pineapples	396 acres
Rice and bananas	106 acres
Fish ponds	1,000 acres
Farm lands	200 acres
Waste	485 acres
Forest Reserve	1,341 acres

SOUTH HALAWA

This section is owned by the Queen Emma Estate (Bruce Cartwright, agent).

Area and Classification:

Total area	3,704 acres
Cane lands	1,039 acres
Pineapple and grazing	894 acres
Forest Reserve, exempt	1,550 acres
Various other lands	660 acres
Waste	181 acres

Cane land leased by Honolulu Plantation Company; pineapple and grazing lands, by Charles Bellina. All leases expire September, 1940.

Forest Fences: The Forest Reserve boundary fence on the east side between Moanalua and South Halawa is all there but is sadly in need of repair. The upper boundary is the top of Koolau range. The lower boundary fence is 1.3 miles in length and was not built on the Forest Reserve line as marked by Forest Reserve monuments, but was built many years ago and is located at least one-half mile mauka. This fence crossed the entire portion of South Halawa and was stock-proof. It is now down and some sections are entirely gone. Portions of it have been rebuilt and supplemented in places by new fences to keep stock out of the new pineapple areas.

Forest Cover: Above the old forest fence where the stock did not run in past years, the forest is in fairly good shape. The small gulches are filled with kukui, while on the upper lands are found ohia, lehua and other species of native trees. In the lower part of the main valley, along the stream, are dense masses of guava. In 1922, we planted above the pineapple lands below the forest fences over 2,000 trees, of which sixty per cent were of the *Ficus* variety; the balance was of five different varieties.

Roads: The whole area is readily accessible to wagon transportation or pack train as the pineapple planters have gone over the entire area.

Fig. 12. *Ficus nota.* Seedling was 10 inches tall when planted in forest land, Helemano, August, 1922. Photo March, 1923.

Stock: At this writing, there are but a few head of stock in this section, not more than forty. They have the run of the entire main valley. The gate in the Forest Reserve is broken and carried away. The fence up the south slope is still standing but needs clearing out and repairing. There are numerous bands of wild hogs roaming over the entire bed of the valley; evidence of their presence is plainly shown by uprooted areas.

Hunting is not permitted in this section but poachers are more numerous here than in Moanalua.

Summary: To make this area stock-proof would require the construction of at least a half-mile of new fence. There are large areas between the pineapple fields which should be planted to trees. Stock should be kept out of the Reserve.

There is more land under pineapple cultivation above the Forest Reserve line than there is outside the Reserve. If this area above the line of the Forest Reserve were held out as forest land, the area remaining would be too small for profitable pineapple growing.

NORTH HALAWA

Owners: B. P. Bishop Estate.

Area and Classification:

Total area	3,470 acres
Cane lands	767 acres
Pineapples	68 acres
Forest Reserve, exempt	1,550 acres
Various other lands	124 acres
Waste and forest in gulch	498 acres

Cane lands leased by Honolulu Plantation Company; pineapple lands by Pearl City Fruit Company. Lease expires in 1940.

Fig. 13. *Ficus macrophylla* seedling fighting its way out and above the uluhi or staghorn fern in forest lands, Waipio.

Forest Fences: Forest fence constructed along line of Forest Reserve and is in good condition on the ridge and part way into the valley. In the valley, sugar cane is planted right up to the Forest Reserve line and is well protected by fence. The boundary between North and South Halawa is well protected by a steep pali. There is no fence between Aiea and North Halawa. There being no stock in Aiea, a fence is not necessary.

Forest Cover: There is no forest cover for at least three-quarters of a mile inside the reserve except the planting of 5,000 seedling trees which we made in 1921. Fifty-eight per cent of these trees are still alive but are not showing great growth on account of poor soil

and dry land; they need cultivation. Above the three-quarter mile line in the Reserve the native forest is in fair condition.

Roads: A pineapple road has been built right up to the Forest Reserve line.

Stock: There is no stock in this section except a few head owned by the Honolulu Plantation Company and they are held under control by fences.

Summary: No fence construction necessary.

More planting should be done and the trees already planted should be cared for.

AIEA

Territorial Land: Homesteads and United States Army.

The United States Army owns all of this section below the Homesteads except the Aiea Mill site, approximately 200 acres.

Fig. 14. *Ficus macrophylla.* Seedling 12 inches tall when planted in Helemano in August, 1922. Photo taken March, 1923.

Forest Reserve Lands: In Aiea there are approximately 383 acres of Forest Reserve lands. These lands are protected by good fences but the pineapple growers are, with the permission of the Board of Agriculture and Forestry, planting all the area they may select, provided they plant 125 eucalyptus trees for every acre of pines planted. The plantation interests have protested to the Board of Forestry regarding the planting of these lands to

pineapples but the Board sees no harm as they believe that the trees planted by the growers will offset the damage to the land.

KALAUAO

Owned by the B. P. Bishop Estate and Bishop Museum.

Area and Classification:

	Bishop Estate	Museum
Cane lands	604 acres	212 acres
Pineapples	39 acres	14 acres
Forest Reserve, exempt	800 acres	500 acres
Waste	125 acres	475 acres

Leases: Honolulu Plantation Company: Expires in 1940.
Pearl City Fruit Company: Expires in 1940.

Fences: There are no reserve fences across this land.

Forest Cover: No forest cover on ridge for at least a mile. Gulches well filled with kukui. A few koa and ohia occur on the north sides of the gulches.

Our planting of 2,800, chiefly *Ficus* varieties, is doing very well. Seventy-five per cent of those planted are alive. The Forest Reserve line through this section is well located.

Trails: Most of this land is in ridges—one large and two small. On the large ridge, there is a good road up into the pineapples, nearly to the Forest Reserve line. The other two ridges are difficult to traverse except on foot. There is a very short cane road up the small main gulch.

Stock: There is no stock at large in this section.

Summary: There is plenty of good land available for planting to trees and much of it is readily accessible.

WAIMALU (SOUTH)

South Waimalu is owned by L. L. McCandless.

Area: It contains an area of 900 acres.

Classification:

Cane land	Data not made available.
Pineapples	
Forest Reserve, exempt	
Other agricultural land	
Waste	

i *Leases: Data not made available.*

Fences: Forest Reserve fence has been taken down and rolled back out of the way of pineapples.

Forest Cover: Pineapples planted for three-quarters of a mile into the Reserve. In the upper portion, above the pineaples, the forest cover is very thin and ragged. In the gulches, the charcoal burners work well up in the Reserve and wild hogs are numerous.

Trails and Roads: Pineapple roads in this section are poor but they extend well up to the Forest Reserve line. The gulches are accessible only with wagon or on foot. The trails are good.

Stock: There is no stock at large.

Summary: This section needs attention. The forest line should be adjusted. The owner has no exemption on the forest lands. The few trees, 2,100, which we planted in this section are doing well.

WAIMALU (NORTH)

Owned by the Austin Estate (Bishop Trust Company, agent).

Area and Classification:

Total area, approximately	2,411 acres
Cane lands	460 acres
Pineapples	64 acres
Forest Reserve, exempt	1,390 acres
Waste	450 acres
Rice and other land	47 acres

Leases: Cane land—To Honolulu Plantation: expires in 1940.
Pineapples—To Pearl City Fruit Company: expires in 1940.

Fences: There has been a very good fence across this section but it has been taken down and rolled back by the Japanese pineapple planters, who are planting for one mile into the Reserve.

Forest Cover: There is no forest cover worth mentioning for at least three-quarters of a mile inside the present Forest Reserve. Small gulches have scant growth in the bottom lands.

Staghorn fern, which sustains forest fires more than any other form of undergrowth, is becoming established all through this section and will in time cover all open areas below and within the forest. It makes such a dense, heavy growth that no seedlings can come up through it and it climbs over all small trees, smothering them to death.

Fig. 15. *Ficus macrophylla.*. Seedling 12 inches tall when planted in Helemano in August, 1922. Photo taken March, 1923.

The trees in an area adjacent to the Forest Reserve line which we planted in 1922, are showing vigorous growth, but need cultivation. Two thousand four hundred trees were planted here.

Roads and Trails: Pineapple roads up to and inside the Forest Reserve. In the main gulch there is a wagon road for a distance of four miles.

Stock: There is no stock at large in this section.

Summary: Pineapple people have taken considerable Forest Reserve land and are working up more, preparing to plant.

WAIAU

Owned by the B. P. Bishop Estate.

Area: 2,227 acres.

Classification:

Cane lands	325 acres
Pineapples	95 acres
Forest Reserve, exempt	1,360 acres
Rice land	28 acres
Waste and gulch	419 acres

Fig. 16. *Ficus macrophylla* growing in a camp at Wahiawa; 18 months old.

Leases: All above the Government Road to the O. R. & L. Company, who sublease to sugar and pineapple interests.

Fences: The fence on Waimalu-Waiau boundary is in good, repairable condition. The fence crossing this section to a pali in Waimano is in bad repair. Only about a third of this fence is standing and this is supported in most part by live trees and staghorn fern.

Forest Cover: Very light and scattered cover in vicinity of Forest Reserve fence; above fence, forest quite scant; some good ohia and a few fair koas.

The staghorn fern is rapidly encroaching upon the forest in this area. The very extensive stands of this fern are a real source of danger, for it burns readily and rapidly, making an extremely hot fire.

Trails: Cattle trails, well marked, up close to fence line. Good hiking trail up from Waimanu home or on the Waimalu-Waiau boundary.

Stock: No stock at large.

Summary: This is the first section where the Forest Reserve line seems to be placed well up in the existing live forest. This is a good place to observe the native forest cover, as this portion of the Ewa Reserve has been protected for some time; the trees show marked evidence of going back.

WAIMANO

Owned by the territory of Hawaii, 660 acres; O. R. & L. Company, 450 acres (fee simple), and other small holdings.

Classification:

Cane land	450 acres, O. R. & L. Co.
Pineapple land	Data not available
Forest Reserve	625 acres

Fig. 17. Forest Reserve lands, Waimalu, converted into pineapple land. Forest cover in gulches destroyed by fire during process of clearing.

Leases: O. R. & L. Co. to Honolulu Plantation.

The Home of the Feeble Minded, located in this section, is doing good forestry work.

Fences: The Forest Reserve fence is in need of repair, only about one-third standing. Cattle may enter this section from Manana.

Forest Cover: Gulches are well filled near the Forest Reserve line. Ridges slightly covered. Good, heavy cover, mauka. Staghorn fern is getting a good foothold along trails and fence line.

Trails and Roads: All parts easily reached on foot—good trails. The Honolulu Plantation Company has a good ditch trail well up the main gulch to their upper intake.

Stock: No stock is pastured in this section.

There are a large number which wander over from Manana, as the Forest Reserve fence is all down between the two sections.

MANANA

Owned by the Oahu Railway and Land Company.

Area and Classification:

Cane	350 acres
Pineapples	320 acres
Forest Reserve, exempt	1,180 acres
Waste	Not known

Leases: Honolulu Plantation Company,
Libby, McNeill & Libby Company,
Small holders of pineapple land.

Fences: The Forest Reserve fence at 1,100 feet elevation is now down and in need of repair. No attempt has been made to keep fences in condition.

Forest Cover: The main gulch is well filled with kukui trees which are slowly creeping up the small draws on the sides. Ohias in bottom and sides rather scant and scarce. Koas on the south slopes only start about one-third from bottom and extend to one-third of the top. The whole area is about two-fifths covered.

Trails: In the gulches, wagon roads go up to the top of the ridge where the pineapples are cultivated. On the main ridge there is a good truck road well up to the top of the ridge. The approach to this road is the turn at Pearl City and through the Plantation camp at the top of the hill.

Stock: This is one of the main feeding places for the Oahu Railway and Land Company's stock. There is more stock in this section than any other place between Moanalua and Waimea.

WAIAWA

B. P. Bishop Estate, owner.

Area and Classification:

Cane land	1,740 acres
Pineapple land	967 acres
Forest Reserve, exempt	4,000 acres
Waste	3,733 acres
Other lands	190 acres

Leases: Honolulu Plantation Company.
Oahu Railway & Land Company—all above Government Road.
Small holdings.

Fence: This fence has been kept up in places where it crosses trails. It is in the same general rundown condition as all the other fences along this reserve. At times, there are indications of a few head of stock inside the reserve. The boundary fence between Waipio and Waiawa is in poor condition.

Trails: Pineapple roads and trails come close to the Reserve. The Waihole Water Company's trails cut into the very center of this section.

Forest Cover: This section of the Reserve carries a reasonably good cover, the majority of the trees appear to be strong and healthy. The gulches are well filled with koa, ohia and kukui, also numerous stands of mango, breadfruit and bamboo. There are not as many wild hogs in this section as are found in other sections at the same elevation.

Stock: At certain seasons of the year there are indications that stock breaks through from Manana (O. R. & L. Co.'s cattle) and have the run of this land in the vicinity of the Forest Reserve fence.

Summary: The plantings we made in this section amount to 4,000 in several different locations and all are doing well.

WAIPIO

John Ii Estate, owner.
Area: 16,250 acres.
Classification:

Cane lands	5,043 acres
Pineapple lands	4,712 acres
Forest Reserve, exempt	5,000 acres
Rice and kula	302 acres
Waste land	1,193 acres

Leases: Oahu Plantation Company,
Pineapple lands to Hawaiian Pineapple Company and Libby, McNeill & Libby.

Fig. 18. Native forest in pocket back of Kahuku.

Fences: Forest fences across this section are in better condition than any other part of the line of Ewa Forest Reserve. Ii Estate maintains them and also a large area is fenced outside the Reserve for the protection of an area planted to trees.

Forest Area: Area inside of Forest Reserve fence well covered; gulches filled with kukui type of forest. The ridges are heavily covered in places with koa and lehua. In the past, this section has been worked over for wood. Numerous wood roads and trails are scattered over this area. Apparently only broken and fallen trees were used for wood; as the result of this, many of the trees now standing are quite fine specimens.

The owners of this section have been engaged in reforesting much of the land outside the Reserve. They have spent considerable money in planting and caring for a large area of eucalyptus trees. They still maintain a few men, growing and planting.

We have planted up several small areas in this section on several different ridges and slopes. These trees are all growing well.

The staghorn fern is a serious obstacle to planting in this section. It is also a serious menace to the remaining forest as it dries out quickly and burns like tinder.

Trails and Roads: As this section is devoted to pineapple culture well up to the forest line, wagon roads extend up all the valleys and on most of the ridges.

Stock: There is no stock at large in this section.

WAIANAE UKA

U. S. Army lands. This entire area is devoted to military use.

The area is fenced on all sides.

No stock is permitted to be at large.

The area included in forests is fully protected and additions by further plantings are being carried on.

The Army has planted about 20,000 of our trees in this area. Better than 60 per cent of these are now growing.

WAHIAWA

Owners: Territory of Hawaii.................................152 acres
Waialua Agricultural Company........................100 acres
Wahiawa Water Company...................................
A number of homesteaders and other small holdings.

Fig. 19. This area adjacent to that shown in Fig. 18 carried the same forest cover until it was destroyed by stock.

With the exception of a few hundred acres of cane, all the agricultural land in this section is devoted to pineapple culture. There are two dairies operating here. Their stock is kept in herds. At times they get away and wander over into the U. S. Army lands where they have done some damage to trees planted by us.

Fences: There are no Forest Reserve fences across this area and from all indications the fence was never constructed beyond the boundary of Waianae Uka and Wahiawa. The Wahiawa Water Company has a water reserve adjacent to the Forest Reserve line which is kept fenced and all trespassing is prohibited.

Forest Cover: Wahiawa above the Forest Reserve line is well covered, and with the plantings made by us below the present Forest Reserve line, Wahiawa is well taken care of. There is room for more plantings. Hand sown *Ficus* seed is getting a good start in this section.

Trails: Pineapple and old wood roads reach into all parts of this section. The Wahiawa Water Company's ditch trail, which is up the south fork of the north branch of the Kaukonohua stream, will take one up into the very heart of this section.

Stock: There is no stock at large.

PAALAA

Owned by the Waialua Agricultural Company and the B. P. Bishop Estate.

Classification:

Sugar cane	800 acres
Pineapples	3,600 acres

Fences: In 1906, there was a fairly good fence across this section, well up into the forest between the 1,200 and 1,600 feet contours. There are only traces of this fence to be found now. If it is to be reconstructed, the Forest Reserve line should be brought much lower, at least to the limits of the present pineapple areas and to include the areas which we have already planted, at least 100 acres.

Forest Cover: The forests in this section have been protected during the past decade and are now in fair condition. Logging for firewood has been rather hard on some portions during the past few years but they are recovering and have opened up an area, giving us a chance to plant in sheltered places.

Trails and Roads: Pineapple roads and wood roads have opened up this section so that all parts are accessible.

Stock: There is no stock at large.

KAWAILOA

B. P. Bishop Estate, Owner.

Area: Total area 14,250 acres.

Classification:

Cane lands	4,475 acres
Pineapple lands	2,200 acres
Forest Reserve	None
Planted to forest	1,000 acres
Waste lands	3,200 acres
Pasture, etc.	3,375 acres

Leases: Waialua Agricultural Company.

Fences: At one time (prior to 1910), there was a good forest fence across this section above the 1,000-foot contour line. On account of the withdrawal of stock from this land, the repairs on this fence were not kept up so that little of it now remains.

Forest Cover: There are some good stands of koa and ohia in detached areas. Staghorn fern is very abundant, covering large tracts of land.

The Waialua Agricultural Company has made very extensive plantings of timber trees and now has a commercial forest covering approximately 1,000 acres. A considerable part of this area was planted some ten years ago and many of the trees have attained remarkable size. Various species of eucalyptus constitute the bulk of this planting.

The Waialua Agricultural Company has been getting firewood out of the native forest and we have planted 7,880 trees in some of the areas which have been cut over. These are making good growth.

Trails and Roads: Wagon roads built for logging purposes extend well up into the native forest. The Hawaiian Pineapple Company is now opening up considerable areas for pineapple culture and is improving the roads.

Stock: There is supposed to be no stock in the mauka lands of this section. They do break through the boundary fence from Waimea, however, and work their way for a mile or so into Kawailoa. On one occasion, they destroyed numerous trees which we had planted.

WAIMEA

A. W. Van Valkenburg, et al, owners.

Area: Total area, approximately 5,710 acres.

Classification:

Ranch and waste lands	5,310 acres
Pineapple lands	400 acres

Leases: Ranch lands to O. R. & L. Company.
Pineapple lands to various lessees.

Fences: A stock-proof fence is maintained on boundary between Waimea and Kawailoa. Pineapple lands all fenced to keep stock out.

Fig. 20. Campbell Estate lands at Kahuku, a small portion of which was fenced and planted in 1922. This area is to be made a part of the proposed new Forest Reserve.

Forest Cover: The forest cover is good only in spots and, upon examination, it is found that these good spots are on steep hillsides or flats inaccessible, or nearly so, to the stock which has the run of this entire area.

In 1922, we planted 2,500 trees in protected places in the lower lands of this section. In July, 1922, I made a trip well into the interior of Waimea and scattered seeds of *Ficus macrophylla.* A few months later I found numerous seedlings which had taken hold and were growing.

Stock: This area is made to do heavy duty as grazing land. The stock penetrates to the very crest of the Koolau mountains.

KAHUKU SECTION

Comprises the following land divisions:

Kaunala, Pahipahialua, Opana, Hanakaoe, Kahuku, Keana, Malaekahana, owned or controlled in main part by the Campbell Estate, and has an approximate total area of 15,000 acres.

Classification:

Cane	2,310 acres
Pineapples	2,513 acres
Pasturage and other lands	10,204 acres

Leases: O. R. & L. Co., who sublease to various lessees.

Fences: The only fences on these lands are for the protection of sugar cane, pineapples and one small section of forest land fenced in 1922 by the Kahuku Ranch and O. R. & L Co.

Forest Cover: There still remain in the upper lands some of the native forests in surprisingly good condition when one considers that this entire section has been used as grazing land for many years. In the upper forests, one sees larger koas than are found in any other part of Oahu. This land would probably come back into forests to some extent if given protection from stock.

In Kahuku, a small area (25 acres) was set aside in June, 1922, fenced and planted. All these trees are doing well. In the one year that this has been fenced you can see an improvement in the undergrowth.

Trails and Roads: This entire section is quite accessible; some pineapple roads reach well up on the ridge while in the gulches and on the higher levels there are good horse trails.

Stock: Outside of the areas fenced off for cultivation and the 25-acre forest tract mentioned above, stock has the run of this entire section up to the very crest of the Koolau range. As these lands join Waimea on the crest of the ridge, it can be seen that the entire watershed at this end of the island is given over to grazing.

H 109 at Kaiwiki

While we do not recommend H 109 cane for high elevations, we find much interest in the showing it has made at 1,800 feet elevation at the Kaiwiki Sugar Company. The following data, on a small area of this cane recently harvested, has been supplied us by Mr. James Johnston, Manager of that plantation:

Cane, H 109;
Second ratoons;
1,800 feet elevation;
Area, .322 acre;
Tons of cane, 13.03;
Brix, 18.7;
Pol., 17.4;
Purity, 93.0;
Tons of cane per ton of sugar, 7.41.

H. P. A.

Overhead Irrigation at Hawi

By J. S. B. Pratt, Jr.

A very detailed study was made of the overhead system of irrigation now being installed at Hawi. Manager Henry Hind very kindly supplied data and every assistance possible in the inspection of the system.

Overhead irrigation is not new to the Islands or to Hawi. Maui Agricultural Company had a small test some years ago. Makaweli has had a small field of about six acres under it. Mr. John Hind, until last month manager at Hawi, has been experimenting with it for years in a small way. In fact, Hawi has been a center for experimenting in new loading systems, implements, etc. But Manager John Hind has gone beyond the experimental stage with overhead irrigation, and has installed a system that will change his entire plantation conditions. He has been ably assisted by his sons, Henry Hind, now manager; Oswald Hind, head overseer; by the chief engineer, W. B. Woodside, and the rest of the plantation staff.

Hawi Mill and Plantation Company is on the northernmost point of the island of Hawaii, the north Kohala plantation. It is subject to strong dry winds and dry weather. The soil is a very porous granular clay to loam.

The plantation has a cane acreage of 3,750 acres, 2,073 of which are irrigated. Due to labor and water shortage, this year's crop is very small.

To understand what the overhead system means to Hawi one must really know what Hawi has been up against. All of the Kohala plantations have a shortage of water during the summer months. Due to the porous nature of the soil, irrigating under the old system is a difficult problem. Water reaches with difficulty to the end of a line of 30 feet. This means a loss of water in both ditches and lines from seepage. Under the old contour system, it required 1,300,000 gallons of water per day to take care of a 100-acre field. Under the overhead system 750,000 gallons are estimated as being the required amount. At present, many of the fields have had to be neglected because of labor shortage, and owing to the poor stand in the ratoons, caused by the inability to get on water after harvesting, and to the lack of water to properly care for them. It is expected that this condition will be entirely overcome by overhead irrigation. At the end of this article are given the advantages and the disadvantages of the system as the writer sees them.

Knowing Hawi's conditions, and seeing how perfectly the system is working, one feels justified in commending the system for Hawi even though the initial cost is a big objection, but which is really the only one that could be raised. After seeing the system work, it is the writer's opinion that it could be used to advantage in Hamakua and many plantations in the Islands.

Hawi this year made a rational move. Mr. Hind's 2-acre experiment that he has had a number of years, proved to him the merits of the system. Already a 100-acre field is installed. Another 88-acre field is being laid out. Next year, of

their entire plant cane area of 500 acres, possibly half will be in the new system if this year's extensive trial justifies such a course.

The costs at first ran high, naturally, as much experimenting had to be done. The system when done on a large scale so that pipe, fittings, etc., can be purchased on a large order, can be installed for a cost of between $150 to $175 per acre. There are so many factors that enter into this, largely the nature of the terrain, that no set rule can be made for each field. In fact, the system must be modified for each field, and with a 25-foot contour map of the field, one can do practically all of the figuring of the installation in the office.

The installation of the overhead irrigation system is an engineering rather than an agricultural problem. After it is installed, the field is handled in cultivation as an unirrigated plantation would be, except that moisture can be absolutely controlled during the dry season.

Laying Out the System

As has been said, every field is a problem in itself, and largely an engineering problem. A contour map of 25-foot intervals is prepared, and from this practically the whole system can be laid out in the office.

Field Hoea No. 12, the 100-acre field first installed, was an even field, at an elevation of 340 feet. To give enough head, 920 feet of 6-inch main line was laid back to the 400-foot level. About 30 pounds pressure is required at the trunk line.

In the new field, No. 10, of 88 acres, it was figured that a saving could be made instead of running so far back to give the initial head, by placing an electric pump at the head of the main line, to give a pressure of 40 lbs. The saving in pipe would about pay for the pump. The new field has a branch main line.

The Overhead System For Ideal Layout

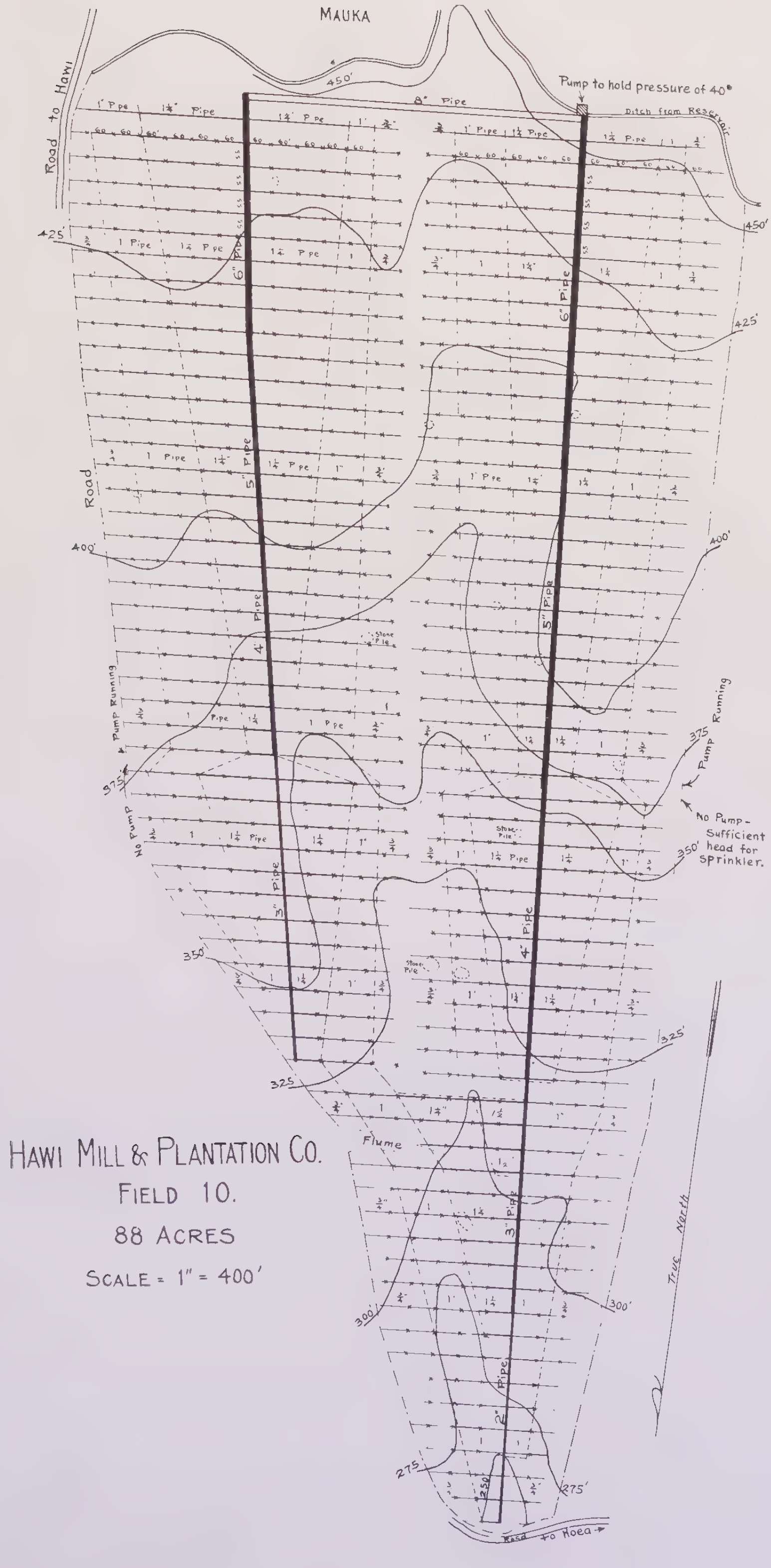
An ideal field layout would be a rectangle with the trunk line going down the center, and laterals branching from its both sides at a distance of every 56 feet (14 lines of cane, 4 feet wide). The standpipes would be 60 feet apart, and the pipes to supply the system would have to be figured from tables of pressures. Optimum length of laterals would be 400 feet.

Tables of Pressures

Weston "Friction of water in pipes."
The Pacific Woodstave Pipe Company's literature.
Remco Pacific Woodstave Pipe Company's literature.

These three works have been consulted for pressures for the conditions in question. The plantation has prepared a chart for their use, to show what reductions to make in sizes of pipe for different distances on lateral and main line and still give 30 lbs. pressure at the trunk line.

Perhaps the best way to describe Hawi's installation is to take it up in detail. Pictures were taken to bring out details hard to describe, and these will be seen at the end of the report with a map of the new field (Field 10) now being put in.



HAWI MILL & PLANTATION CO.
FIELD 10.
88 ACRES
SCALE = 1" = 400'

Covering of Pipe.

Hawi covers the main line pipe only. A furrow is made, the soil shoveled out. Then a subsoiler, pulled by a two-mule team, one animal on either side of the ditch, loosens more soil, for further shoveling. Here a Martin road grader, as used by Kilauea, could be used to advantage, unless there were too many rocks. The lateral pipes are not covered, but are laid beside the rows of cane so as not to interfere with cultivation.

The field is to be run for one plant and four ratoons, or ten years, and the pipe will be so depreciated by that time that when the field is plowed again, the value of the lateral pipes will count for little. With Kohala's salt air, they will be about rusted out anyway, so that plowing can be considered at that time. The main lines are only just buried, possibly 8 inches. Laterals will not give trouble in the harvesting as cane will be flumed. They can get water from the box at the head of the main pipe.

Main Lines

The size of the main line depends on the contour, the heads, length run, etc. The first field (Hoea 12) laid out was as follows: From an elevation of 398.6 ft. a 6″ woodstave pipe was run 920 feet to the top of the field, elevation 340.2 ft. The pressure here of 25 lbs. is reduced to 14 lbs. when all sprinklers for a day's irrigation are in use. From here the main line continued as 6-inch for 2,500 feet, to elevation 200.3 ft., head 197 ft. From then on to the bottom of the field, 1,400 ft. more, a 4″ wood pipe was used.

In field 10, shown in Figure 1, the main line is not run back to give head, but a pump is installed to hold 40 pounds pressure. One main line has 6″ reduced to 5″, reduced to 4″, reduced to 3″, then to 2″. A large lateral 8″ carries to the other main line. This pipe could have been smaller, but was ordered before the pump idea was decided upon, to be the pipe run back for head. The line is reduced from 6″ to 5″ to 4″ to 3″ to 2″, as shown on map of field in Figure 2.

Pump

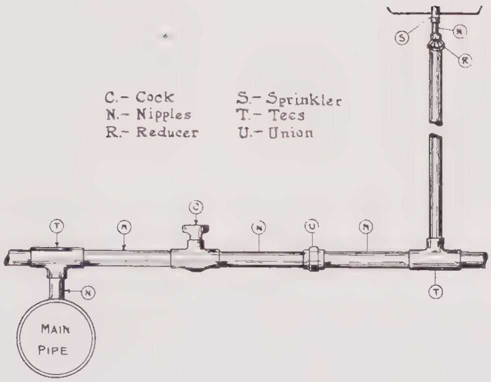
It will be noticed that the pump will only be in use for the upper half of the field. The lower half will have enough head of its own.

Lengths of Main Pipe

The woodstave pipe is made in various lengths. It is of redwood or spruce and covered by tarred cloth. Several companies make such pipe, and there are local agencies for the pipe in the Islands who can supply details as to cost, friction, etc. It was decided that the wood pipe is the best for the main line. Laterals are well galvanized.

Fittings

No set fittings can be given, because the requirements of each field would be different. There are no valves on the old field. The new field has several large 8-inch and 6-inch valves at the head of the main line by the pump to let water go into the two systems. Elbows, nipples, reducers, unions, and tees are all needed on the lateral. For example, from the 8-inch pipe line to the first standpipe would be needed the following: Fittings run into considerable money, and very careful figuring will make a saving.



Screens

A very ingenious device has been worked out by Engineer Woodside to keep the pipes from clogging with dirt, "limu," etc. A box flume carries the water from the main ditch. A box one foot deep settles all the silt. This box is lower and has a small 6-inch gate to sluice the mud out. Then comes in the flume, a waterwheel working a set of scrapers which scrape all moss, etc., that might settle on the screen. The screen is of a very fine mesh. All water passing through the screen, then, into the main line is quite free from foreign matter, etc. Later, of course, when the lateral pipes rust, there will be some sediment in the pipes, but as the standpipes are ten feet high, the sediment could be blown out occasionally at the end of the laterals.

Gauges

A pressure gauge is installed at the head of the field on the first lateral, but others are placed in occasionally to check the pressure on the various lines.

Pressures

A pressure of 30 lbs. is wanted at the main line.

Laterals

Hawi has a good wind that assists them in distributing the spray from the nozzles. They have placed their laterals 55 feet plus off the main line, probably 56 feet, as the lines follow the rows of cane, and as the rows of cane are planted 4 feet apart, 4 times 14 equals 56 feet. Standpipes are 60 feet in the laterals.

The amount of water going into the lateral is regulated by a one-way cock. They found that two one-way cocks were cheaper to put in than one two-way cock, where laterals go both sides of the main line.

The size of lateral pipe varies from 2 inches down to ¾ inch at the last standpipe.

Laterals are not buried.

It is very essential in order to make a saving in length of pipe for the laterals, that they run perpendicular to the main line, and naturally, then, the rows of cane have to follow the same way because the pipes would interfere with cultivation. The perpendicular would be the shorter line. On a lateral 700 feet long, as in

the first field laid out at 90°, if it came out at 45° instead of 90°, the lateral would have been 989 ft. long. At 60° it would have been 808 ft., and at 80° it would have been 709 ft.

Optimum length of laterals is thought to be 400 feet, more or less, depending upon the individual layouts.

Standpipes

By roadways where the prevailing wind catches the spray, the standpipes are only 5 feet high. They are 10 feet high in the rest of the field. When the field was first tried out, the standpipes were made 5 feet, so that adjustments could be made very quickly on the nozzles. When the system worked well, they were lengthened to 10 feet. Hawi's cane is much shorter than at some places, and the strong winds there give a very good distribution. Occasionally it was found that the spray at the road would not be given equally so that there were a few dry spots. The field planted is D 1135, 3 feet high and an excellent stand, showing that the water is well distributed under their conditions.

Skinner System.—To give a better distribution by the roads where the wind was more variable, the Skinner system of an overhead pipe for the first standpipe was tried with success. This was set back from the road. It clogs more than their type of sprinklers.

Standpipe.—All methods of placing these were tried, on equilateral triangles, on squares, etc., but the system decided on finally has the first standpipes 5 feet high, at the edge of the road by the main line (where the wind is in that direction), and then 60 feet in the next standpipe, so that they are all in a row. The reason the standpipes are 60 feet apart is to save cutting pipe, which comes in 20-foot standard lengths. The standpipes inside, as has been said, are 10 feet high and are not guyed. By each standpipe, however, is a piece of 2 by 3 driven in, to which the pipe is wired.

Each lateral is numbered on this wooden block, so that a lateral may be referred to, or a record system be kept on the irrigation.

Size of Pipe of Standpipe—Three-quarter inch pipe with bell reducer to 3/8″ and nipple to the sprinkler.

This distribution of standpipes is working nicely at Hawi. Places without wind and with taller cane may have to have them higher and closer. Makaweli had them 80 feet apart and 25 feet high, guyed, but Manager Baldwin there, believes that they should be 60 feet apart. The higher, the more difficult, of course, in removing the sprinklers.

Sprinklers

All types of sprinklers have been tried, but none have done so well as the one Hawi makes in their own shops. It is made of brass and costs 45 cents. A detail of it is given in Figure 3 as a picture. The features of their sprinkler are these: There are three holes at 45° for the water to force itself in the revolving part. The upper portion has two nozzles at 45°, and about 6 inches long, and the point is tapered to force the water further.

The number of sprinklers per acre at 56′ x 60′ is 13.

The water that leaks through the top of the sprinkler gives a better distribution near the standpipe.

A new feature to be tried is a washer to be placed in the lower part of the sprinkler, with various sized holes to regulate the pressure at each nozzle. To establish what size washer to use, a pressure gauge is put on the standpipe, and from a table they have prepared, the opening in the washer necessary to give the required pressure at the nozzle is found.

The amount of water to go through each sprinkler is calculated at 4 gallons per minute per sprinkler for 12 hours.

Irrigating

The water is turned on for 12 hours in one battery of about 160 sprinklers. There is a day man and a night man. The night man turns on another battery. This they figure is equal to 1½-inch irrigation.

In Field Hoea 12, the 100 acres are done in 7 days by the two men. There is no actual data as yet on the amount of water, but they claim 750,000 gallons will be what 100 acres of overhead irrigation requires.

Clogging

There has been no trouble so far with clogging of the sprinklers. The fine mesh wire screen at the head of the main line keeps out foreign matter, and no rusting has yet taken place. But in big cane, if one clogs, a forked stick can be used to quickly raise the upper part of the sprinkler, and the water coming at 25 pounds pressure will blow out any foreign matter; otherwise, the pipe will have to be unscrewed.

The clogging is one of the few objections that could be raised to the system, but Hawi has apparently thought out all of these troubles in advance. The sprinkler in two parts with the screen to strain all water entering, may overcome any future trouble.

Planting

The field is plowed, harrowed and made ready for furrowing. The main line pipe is installed and covered, and each lateral is made one length with cock on each. The field is then planted in straight rows, 4 feet apart, and perpendicular to the main line. The laterals follow every fifteenth line in, close to the cane, so that line can later be cultivated.

The cane could be planted with the new Larsen, Moler or Broadbent unirrigated land planter. If planting is done in wet weather, there need be no haste in getting the laterals in. The laterals are not placed in until the cane is planted.

Two men working together on a lateral can put in standpipes, sprinklers and 2,250 feet of lateral in one day. The lateral pipe is placed in the field before planting but is not screwed together. It is not buried.

Roadways

Roadways should follow main lines, for laterals have cocks to be turned.

Labor in Irrigating

As has been mentioned, one man runs a battery of 160 sprinklers for all day. The night man changes to a new set. This leaves the man free to hoe, fix sprinklers in trouble, etc.; two men seven days or 14 men for 104 acres. They could take more acreage especially while cane is small. In the old system, one man

hardly did three-quarters to one acre with big water, or some 130 men for one round of irrigation, instead of 14 in the new system.

Costs

Costs were not gone into very thoroughly, as the costs would vary considerably for each field installed. A plantation installing an overhead system would have to figure it out on an exact cost basis for each field. The first field of 100 acres cost $168 per acre, but on a large scale, the cost could be made for $150, it is believed. The main expense is in pipe and fittings. Installation and hauling should not be much over $12 per acre.

The cost is the big item to criticize in the system, but $150 per acre, to cover a ten-year period is not a bad item, especially when one looks at all the advantages which are given at the end of this article. The saving of labor alone soon pays for the initial cost.

Mistakes and Future Improvements

Naturally, going into a big proposition like this, many little details had to be worked out. Many improvements have been made, and more will no doubt come later.

First. The mistake made in the first field was that the laterals were too long. They were 700 feet and over. The optimum length of the laterals should be 400 feet instead.

Second. Instead of running a long main line back to get head, they believe an artificial head will give them cheaper results. They have electric power there, and only a small No. 10 wire carries the current for the pump. The pump is a "Cameron" from Catton, Neill & Co., size 4", giving 520 gallons per minute.

Third. In the first field the lines of cane were not quite perpendicular to main line. In this way, laterals have little longer pipes than need be.

Fourth. An improvement will be the washer placed in the sprinkler head to give the correct pressure flow through the sprinkler. This is an individual adjustment for each sprinkler, and corrects for unevenness of terrain, etc. Larger size pipe can be used, giving more head through less friction and can be adjusted for each nozzle. Instead of placing an order for several sizes of small pipe, a larger order for one size pipe can be placed, thereby effecting a saving.

Fifth. A weir, or preferably a meter, should be placed at intake, so that actual water data may be obtained.

Advantages of System

(1) *Water Regulation:* Any amount of water may be given, 1 inch or 5 inches, largely depending on time turned on.

(2) *Water Saving:* 1,300,000 gallons per day for 100-acre field under old style, only 750,000 under new, but this estimate has not been checked by actual measurement. No seepage from ditches, but more evaporation.

(3) *Cultivation:* Cultivation is cheap. Unirrigated conditions. Very little hand hoeing. Secret is to get weeds when small.

(4) *Mulch Control of Moisture:* After irrigation, cultivation can be easily given, producing a soil mulch, thereby retarding evaporation and destroying young weeds at the same time.

(5) *Water Immediately After Harvesting:* It is the writer's belief that the failure of H 109 to ratoon at Hawi is largely the inability to get water immediately on the ratoons after harvesting, due to water shortage and to a shortage of labor.

(6) *Labor Saving in Cultivation (Hoeing) and in Irrigation:* This would soon pay for initial expense. For a 100-acre field, one round now costs about $14 at $1 per day. The old style would cost $120 at $1 per day. Even at $200 per acre, labor saving would soon wipe out cost.

(7) *Fire Protection:* Very apparent.

(8) *Hoeing:* Less weeds from dirty ditches, etc. Cultivation by animals under straight lines gives big labor saving.

(9) *Area Saved:* Saving in acres taken up by ditches, watercourses, etc.

(10) *Harvesting:* Harvesting simplified by straight lines. No hapa lines.

(11) *Day and Night Irrigation.*

(12) *Fertilizer:* Fertilizer action not delayed by lack of proper moisture.

Disadvantages

(1) The cost, $150 to $200 per acre, is a big item, but same covers ten years; add interest on money to this. (See item 6 of Advantages.)

(2) Some sprinklers are slow in starting, but are easily started by lifting with a forked stick.

(3) Clogging later on from rust, etc., is possible, but many practical ways may be thought of to overcome this.

(4) Evaporation loss, and loss through some water not getting to the roots through trash and heavy cane, compensated somewhat by less ditch seepage losses.

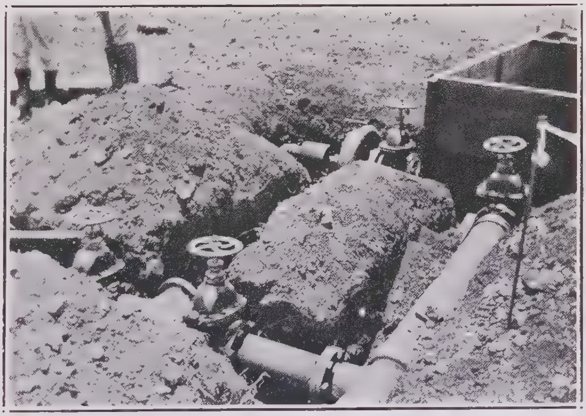
Intake of the Main Pipe line in Field Hoea 12.

This is 920 ft. from the field where overhead irrigation is used.

This water wheel runs scrapers over very fine screen.

Another view of the water wheel.

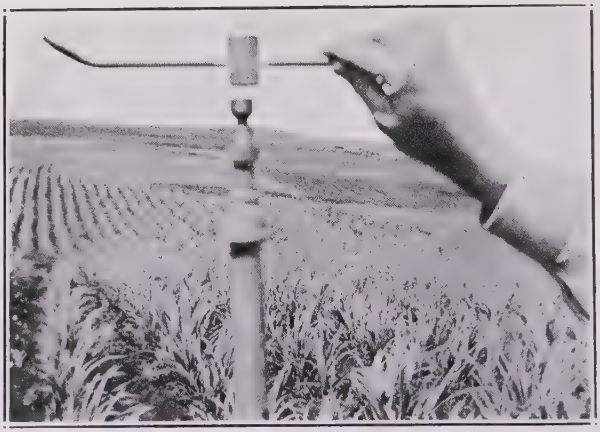
Field Hoea 12, first field planted for use under the new irrigation system. The variety is D-1135 cane. Note stake bearing number of lateral line.



A four-inch electric pump installation.

Silt Box.
Manager Henry Hind standing in box where screen and water wheel will be. (One main pipe line can be seen running to the right, another towards the horizon.) (Note rocky condition of soil.)

The sprinkler is cleared by lifting the upper part from the base.



This view shows the detailed construction of the two parts of the sprinkler. Note that the standpipe is reduced from ¾″ to ⅜″.

Note straight lines for cultivation. Standpipes visible on horizon to right of horse.

This picture shows pipe line running close to the cane row; the standpipe and the pressure gauge can also be seen.

Skinner overhead system by roadway where winds are stronger. This system clogs more than Hind system.

These standpipes are wired to stake as shown here. Each lateral line numbered for reference in irrigation, hoeing, etc.

The Jeswiet Identification Characters of Sugar Cane

By Twigg Smith

Dr. J. Jeswiet, of Java, has established the fact that the arrangement of the small spines or hairs on the eyes and leaves of sugar cane is never the same for any two varieties. He has classified these minute hairs into seventy or more groups.

We first became interested in Dr. Jeswiet's work in attempting to establish the parentage of the seedling grown by Mr. Richard Lyman in Kapoho, Olaa plantation. This was a seedling of H 109, but was thought by several people of the plantations and the Experiment Station to bear a marked resemblance to Yellow Caledonia. We have never been able to secure a seedling of Yellow Caledonia. Repeated efforts have failed. If this Lyman seedling had Yellow Caledonia as its male parent it would be a very important cane to use in our cane breeding work, for thereby an opportunity would be offered to use tassels from the Lyman cane to introduce Yellow Caledonia characters into our seedlings. Mr. Smith has, however, been able to establish to our satisfaction, through the Jeswiet methods, that the Lyman seedling shows the Jeswiet characters of H 146, and that that cane and not Yellow Caledonia is in all probability its male parent.

This information results in saving time and expense that might otherwise have been given in breeding from the Lyman seedling in the hope and belief that it might be of Caledonia parentage. Another illustration of how this work is of commercial benefit to the industry is described as follows:

The best cane for mauka lands, among our established varieties, is Yellow Tip. This cane, unfortunately, is extremely susceptible to mosaic disease and is so sensitive to it, once the disease is contracted, that the yields are reduced to such an extent that profitable crops are hardly possible. D 1135, on the other hand, is extremely resistant to mosaic disease.

We have grown hundreds of seedlings, taking tassels from Yellow Tip, in localities where there were prospects of obtaining crosses with D 1135. Out of 800 such seedlings at the Manoa substation, 200 have been selected for preliminary plantation try-outs on Kauai and Hawaii. This work will be greatly facilitated if we can establish to what extent we have succeeded in actually obtaining crosses between Yellow Tip and D 1135.

Mr. Smith, in examining some of the seedlings, finds unmistakable evidence of D 1135 characters in these Yellow Tip seedlings. There are reasonable prospects that among such crosses we will find varieties which maintain the vegetative vigor and weed-suppressing qualities of Yellow Tip combined with the mosaic disease resistance of D 1135.

Still another instance of the possible benefit from this work will be in establishing definite identifications of the scores of seedling canes which are about to assume commercial significance on the plantations.

The present article deals with the study of ascertaining the parentage of the Lyman seedling.—H. P. A.

As an introduction to the work of establishing the identity of our sugar cane varieties in general, and of determining, where possible, the parentage of seedling

varieties I have taken passages from the published articles* of Dr. J. Jeswiet. This abstract of his work follows:

From the moment that in Java the importance of cane selection was realized, a want was felt for a proper manner of description by which the varieties might be recognized. Without such a description, it is natural that in the culture of many varieties of cane, confusion may cause great losses of time and money as by mixing an early ripening variety with a late ripening one, or the mixing of canes of low and high sucrose content. Also it has often happened that a once condemned variety has reappeared under another name. The same applies to the importation of foreign varieties for which we have no guarantee as to genuineness of character. Therefore reliable descriptions are of great value to check importations as well as to establish our own varieties, giving us an insight into their relation and their origin. It is also of great use in judging the seed consistency of the types obtained from repeated self-foundation.

Method of Description

The stalks of cane can be separated into two groups: Flowering and non-flowering.

The differences manifest themselves towards the flowering period, when the stalks that will flower begin to show changes in the tops. The upper leaf sheath becomes very long and the leaf blades keep getting shorter. The upper internodes which carry the flowers are longer and the eyes are absent.

The non-flowering stalks always become longer than the flowering ones and towards the finish of their growing period form the so-called "top bibit" or seed cane, a series of short joints with strongly developed eyes and root eyes.

I have based my method exclusively on non-flowering stalks. This method, then, is applicable on non-flowering crop cane on top bibit (seed cane) and on the plant cane from 4 to 6 months old, both with the leaf top on. Plant cane below that age also checks, but the hairing on the leaf sheath especially may fail at times. With older cane the hairing on leaf sheath is a safe and reliable characteristic.

Besides the characteristics which indicate the variety we must look for smaller Bertillion marks which indicate the individual within the group. These characteristics must be constant as much as possible and little dependent on exterior influences. Important from a morphological standpoint, they may have little value physiologically.

I believe these characteristics to have been found in the hairing of the eye scale, the leaf sheath and the blade. These groups have proven sufficiently constant and can be used for the description of individuals from the type Saccharum officinarium, as well as in the systematic system of the botanical types of the genus saccharum.

While the shape of the eye may alter in cane of different ages or environment, the hairing suffers least in variation.

Other Characteristics That May Be Used in Determining the Variety

Fairly Good Characteristics

Cork Cracks. Fine cracks in ground tissue which later dry up, leaving marks.

Growth Cracks. Deep cracks running with the stalk sometimes into root ring. Sometimes called wind cracks.

Minor Characteristics

Length and Thickness of Cane. These are greatly influenced by outside conditions, such as poor soil and irrigation.

Color. Is very changeable according to exposure. Never can the stalk color be taken as a basis for classification.

Wax layer. Varies for different locations.

Shape of the Joints. Also may be changed by different causes, such as drought, temporary stagnation or stripe disease.*

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* From the "Description of Cane Sugar Varieties, Part 1, Morphology of Sugar Cane," by Dr. J. Jeswiet, Chief of Division on Cane Improvement at Pasoeroean. Archief, XXIV, Part 1, 1916.

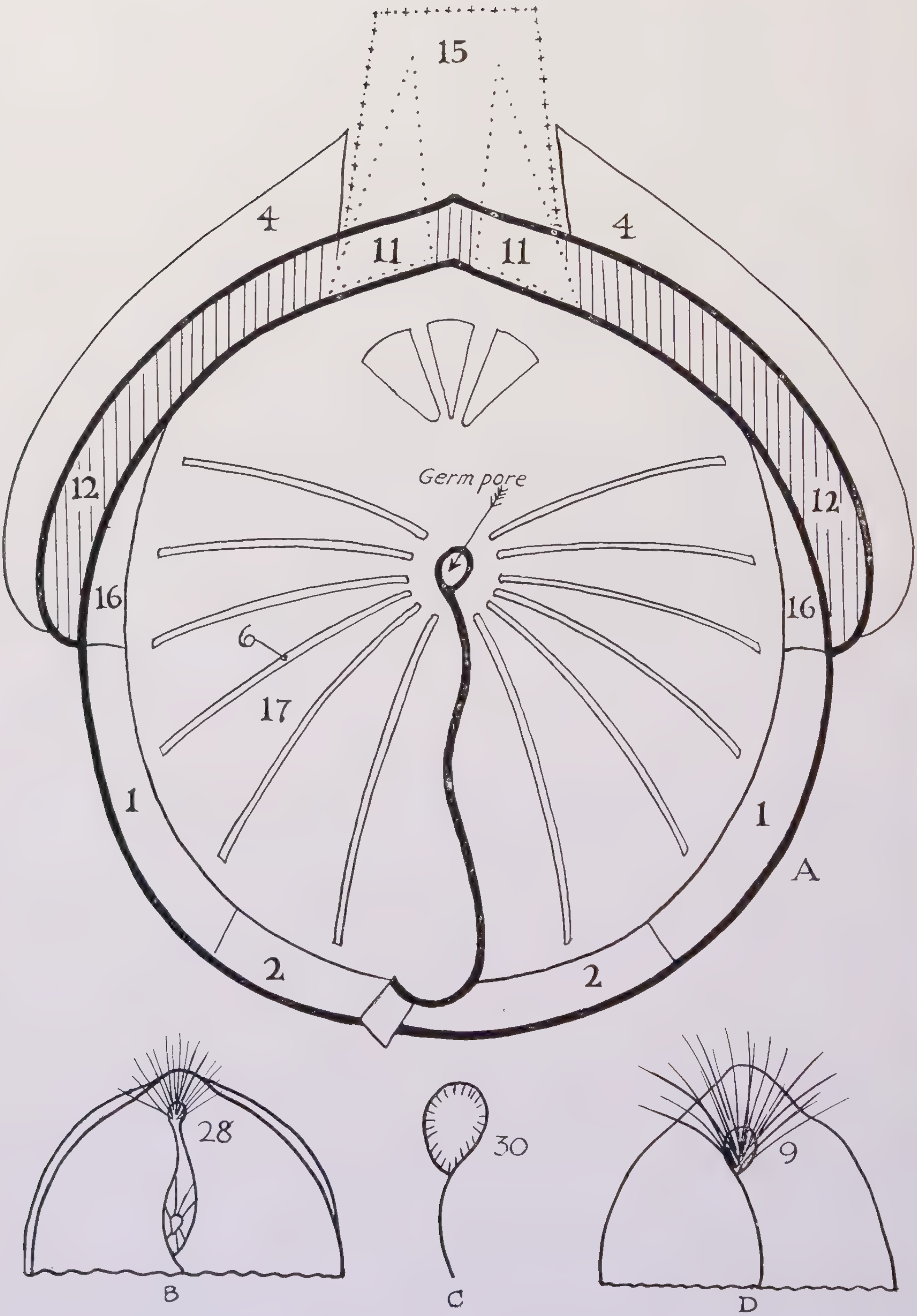


Fig. 1. A. Plan of outside of round type of eye, with central germ pore, radial veins, wings attached about center, and a part of the hairgroups by numbers occurring on that side. B, C and D, groups occurring on germ pore.

Circumference. Length and position of the joints very variable.

Eye Groove. Sometimes present, often absent in same variety and same stalk.

Growth Ring. The zone separating the root ring from the joint, color changeable, but shape and general appearance a useful auxiliary characteristic.

Root Ring. Shape and location reliable.

Root Eyes. The number of rows of root eyes is of great value in classification of the botanical variety.

The Eye

There are two main shapes of eyes, round, Fig. 1, and oblong, Fig. 2. In round eyes the wings are attached above center, in oblong below. The place of attachment is called the wing corner. Round eyes have a more or less central germ pore, oblong eyes an apical germ pore. By germ pore is meant the opening developed by the swelling of the eye through which the young shoot emerges. The scale nerves or veins lead to the germ pore, causing a great difference in appearance between the round and long eyes.

Between these two types of eyes all kinds of transitions exist, but the hairing of the eye remains comparatively constant. The position of the eye in relation to the stalk can be quite different in different varieties. It may be growing in a deep cavity, pressed close against the stalk, or standing clear away from the stalk.

All cane eyes are more or less haired. The kind of hair is very different for the different varieties and is to be found in always reproduced groups making it possible to recognize the different cane varieties. It is clear that both presence and absence of the groups are to be considered. The appearance, extent, as well as the length of the hairs is subject to variation, but in a small number of sticks taken at random an entirely sufficient number of eyes can be found which correspond with the typical hairing.

To facilitate recognition all the hair groups have been given a number as shown in Figs. 1, 2 and 3.

Following is a description of the groups with their specific numbers:

Front View of the Eye

1. Fairly long white hairs on both sides of the eye scale below the connection of the wing; common; of variable extent.
2. Fairly short white hairs, at times interrupted by groups of long hairs, alternating with scale veins, sometimes a strong group of long hairs covering up the short ones; common.
3. White, more or less long, covering up group 12.
4. Long white hairs, sometimes just at base, at times over entire edge, again, leaving top free.
5. White, generally long, mostly in varieties with long stretched eyes as H-146, strongly pressed together, waxed or straight haired group at top of or in between veins, sometimes only on one side.
6. Short brown or black hairs between the veins, similar to growth between veins on leaf sheath; common.
7. Short brown, at times long and white. Nearly exclusive with round eyes, or where there is room above germ pore, not always one definite group, sometimes detached groups.
8. Long white hairs, starting above the wing corners extending nearly to top, leaving top free, growing on junction of wing and scale (extent shown a little short in illustration to make room for groups No. 12-13).
9. Long hairs showing in the germ pore growing on the surface of second scale, very rare.
11. Long white hairs on the edge of wing and blade, or on the wing just below the wing top, generally pressed against the wing, sometimes extending beyond it, mostly waxed.

[* Dr. C. A. Barber in the Memoirs of the Department of Agriculture of India (p. 146, Vol. 8, 1916) says: "The question of striping is always of interest. One would expect in seedlings of a striped cane a larger proportion of cases with striping in the stem. This does not appear to be the case. The striping breaks down completely in the seedlings—when it occurs it is seen in striping of some of the younger leaves. The color of the parent has some little influence, although comparatively little on the color of the seedlings derived from it, the proportion of green being most uniform."] T. S.

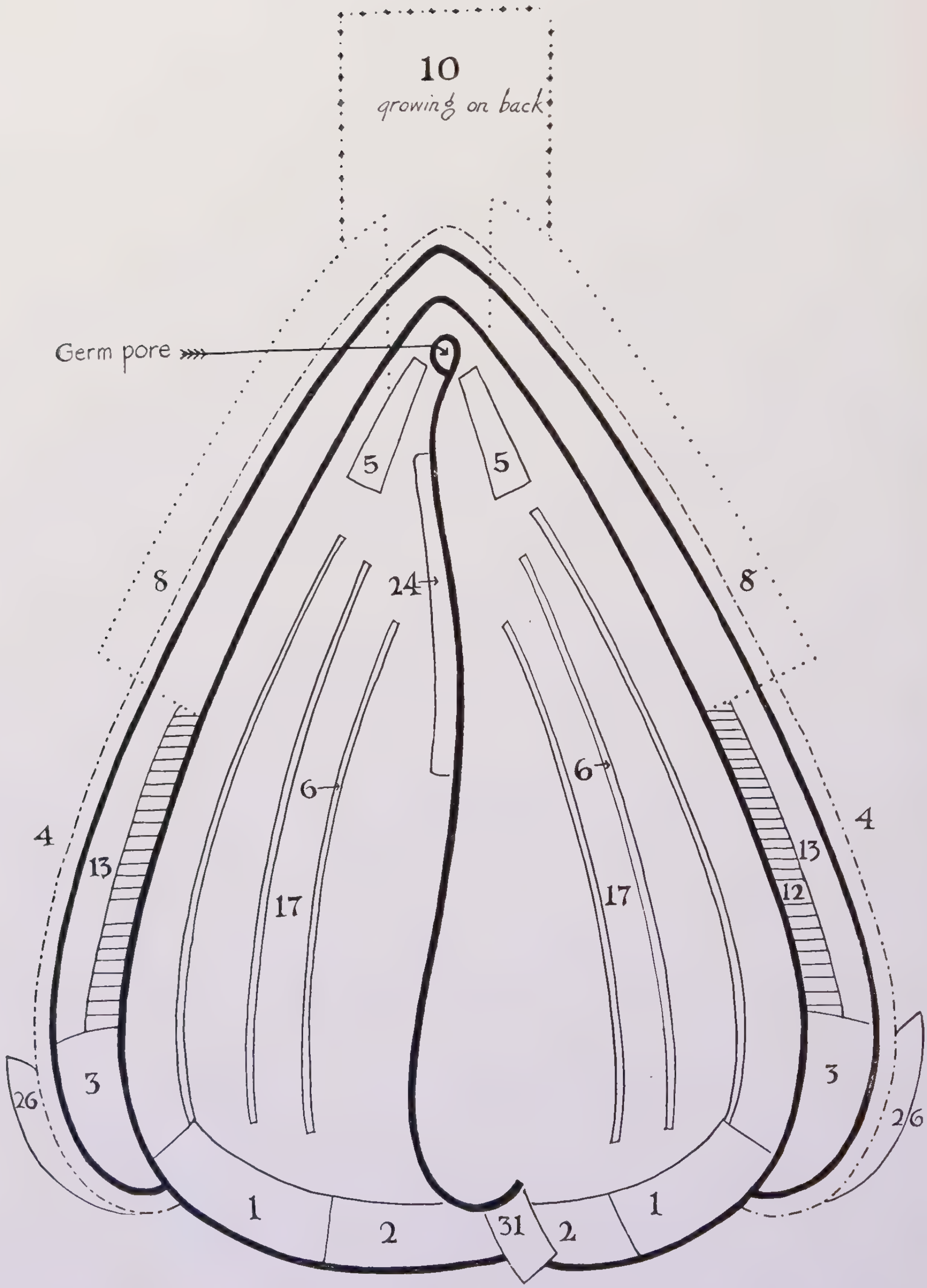


Fig. 2. Plan of outside of oblong type of eye with apical germ pore, veins convergent towards the top, low attached wings and a part of the hairgroups, by numbers, occurring on that side.

12. Adjacent small black hairs, sometimes extending all over wing or only on parts. Primitive and present in all varieties.

13. Long adjacent white hairs, on wing surface, sometimes over entire surface, at times envelop group 11. When group stops, group 12 appears again. Rare.

15. Long white on top of scale at times short and dark. Sometimes occurs by itself as a group, at others a continuation of No. 4.

16. Long white hairs, surface of scale close to wing border line above lateral group 1.

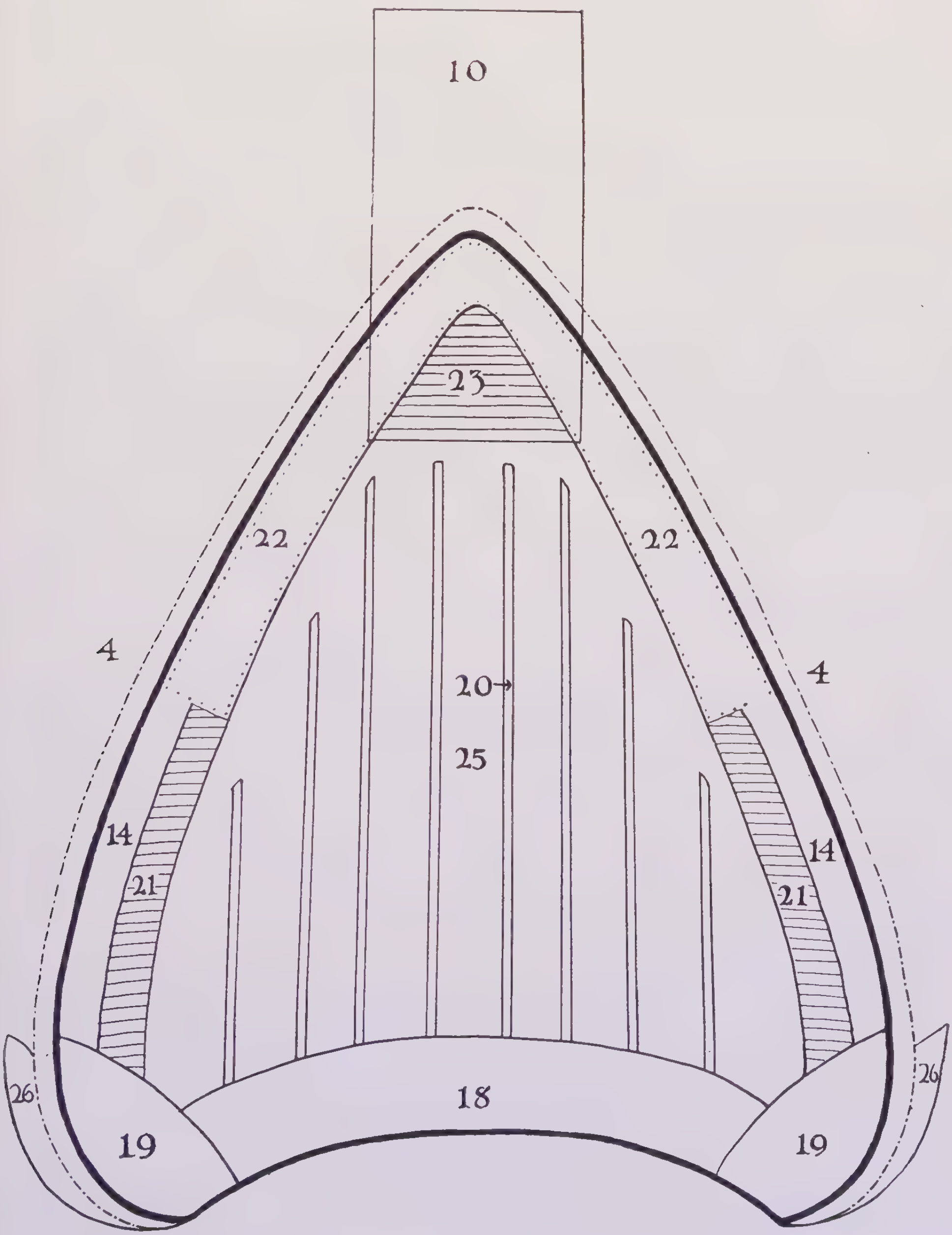


Fig. 3. Plan of back of oblong eye showing, by numbers, part of the hairgroups occurring on that side.

17. Long white hairs lying close together between scale nerves, sometimes mixed in with No. 6.

24. Short white or brownish hairs on top or overlapping edge of scale, generally on upper half, very characteristic.

28. Long white, seen through extended germ pore growing on second scale.

30. Short brown, on edge of germ pore.

31. Long white, at base of overlapping edge, generally pointed down.

Back View of the Eye

10. Long white, generally on the scale between veins but may extend on the wings, varies greatly in number of hairs, often of two parts. When extending on the wings often absorbs wing groups equal to 11 on the front.

14. Long white, similar to No. 13, but on the back—seldom seen in Saccharum officinarium, characteristic for the wild grown varieties.

18. More or less long white hairs on basal edge at back, sometimes only in center, at others clear across, may be a solid line or alternate with the nerves.

19. Long white hairs, sometimes confined to the corner, at others extending towards the center.

20. Scattered short brown hairs between nerves.

21. Short brown hairs, may extend all over the wing. Common.

22. Long white hairs, a narrow ribbon on edge of wing and scale, often a connection between 19 and 10.

23. Short brown hairs on top of scale, connects with short hairing of 21, sometimes covered by 10.

25. Long white between nerves, a silky appearance.

26. Long white in wing corners.

29. Long white only on very wide eyes.

The Sheath and Leaf Blade

Color, waxing, size and position vary too much to be of special use. The shape and hairing of the ligule are an especially good characteristic for the botanical varieties. The joint triangles, the zone right behind the ligule vary considerably in shape and hairing for the different varieties; sometimes they are absent.

The hairing of the sheath and leaf, however, is constant and is of great value in determining the variety. See Figs. 4 and 5.

Outside

Group 51. Soft, silklike, white, long, extending beyond leaf edge growing behind the ligule on the joint triangle, never reaching the midrib, but reaching up to leaf edge, longest at leaf edge, growing smaller towards midrib. Present in all varieties of Saccharum officinarium.

Group 52. Short feltlike white hairs, between nerves on joint triangles (not a very significant group).

Group 53. Long silklike lashes on lower part of leaf edge above joint triangles, often continued up leaf, at times broken off, leaving sharp hooks on edge of leaf, both sides.

Group 54. White hairs on the upper edge auricles, varying length.

Group 56. Long white on edge of upper part of overlapping leaf sheath, *rare.*

Group 57. Long white hairs in center. Very important, changes in extent, may start high or low, narrow or wide, etc. Length of hairs, position and quality variable. See H-109, Lahaina, H-146, etc. Sometimes missing entirely.

Group 59. A ring of hairs on leaf scar, in nearly all varieties in young suckers. Fairly rare in mature cane.

Group 60. Long white lateral groups, rare, a narrow, thinly growing group, example H-109.

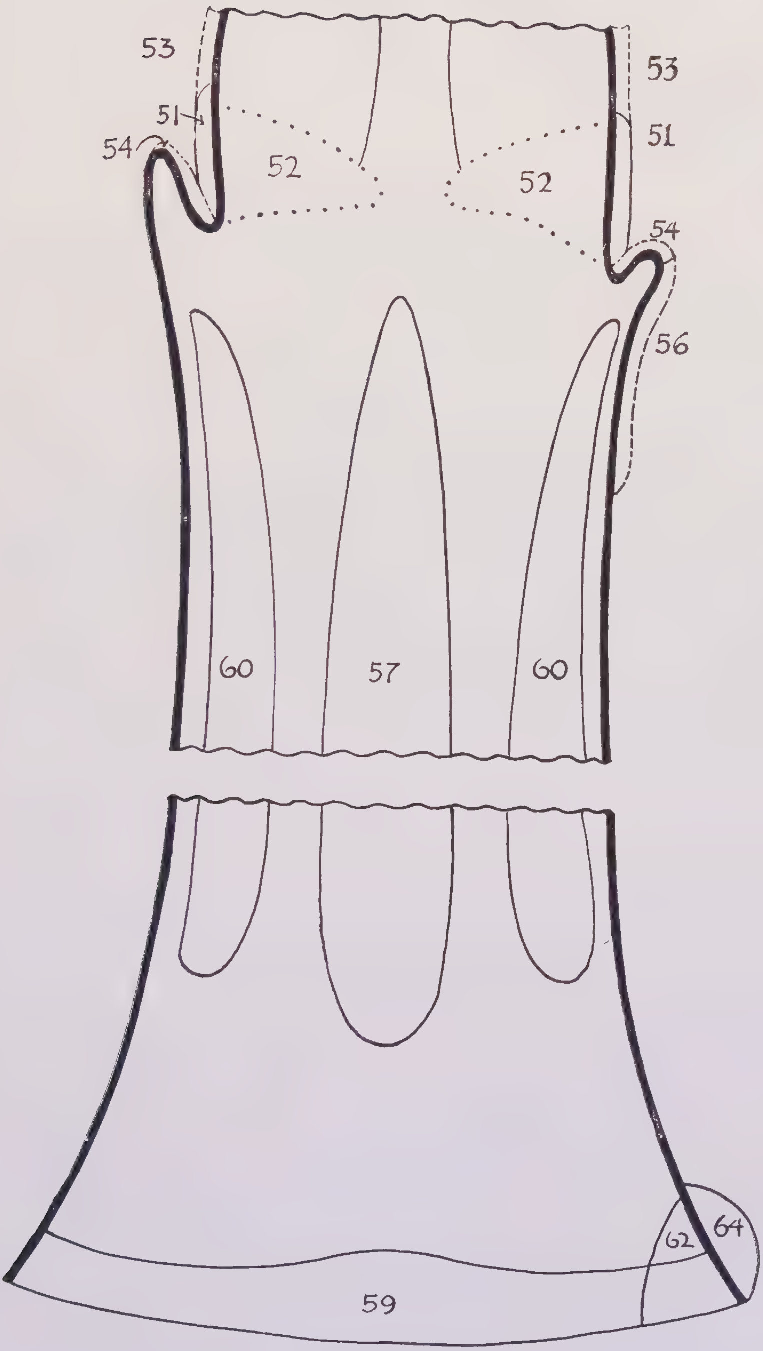


Fig. 4. Plan of sheath and juncture of sheath and blade of the leaf with hairgroups by numbers, seen from outside.

Group 62. Silky, long, white hairs at base, fairly frequent.
Group 64. Long hair on base of upper flap of sheath, fairly rare.
Group 67. Velvet hairing on leaf surface, rare (not shown).

Inside

Group 55. Generally fairly long white, sometimes extends up midrib. Grows on midrib behind ligule, rare.

Group 58. Very short, feltlike, white hairs on joint triangle, group characteristic, generally hidden by wax.

Group 61. Short hairs on edge of ligule, common, generally short.

Group 63. Very short tough hairs, triangular group on midrib behind ligule, varies in length.

Group 65. Single row of hairs growing behind but not projecting above ligule, extending its full length (not shown in drawing), rare.

Group 66. Half free thick hairs on back of ligule (not shown).
Group 68. A double group behind ligule.
Group 69. At base of leaf sheath on the under side.
Group 70. Long soft hairing on long auricle. Fig. 5.
Group 71. Soft white hair on small auricle. Fig. 5.

In order to become familiar with the method used by Dr. Jeswiet I have examined and made drawings of several varieties of our canes. I have found that the hairing of the eyes, leaf sheath, and leaf does appear regularly in the same positions regardless of where the cane is grown.

A Comparison of the Lyman Seedling With H 146 and H 109

As a practical example I have been able to establish the identity of the so-called Lyman seedling, the parentage of which was doubtful. It was said to be a seedling of H 109 and Yellow Caledonia.

The one stool I examined is similar in general appearance to H 109. It differs in growth, whereas H 109 has a tendency to increase in circumference of internodes towards the top, the seedling decreases; also the internodes of the seedling are somewhat larger and barrel-shaped, and very much softer.

From the plan in Fig. 6 it will be seen that the pollinated tassels of H 109 were taken in the vicinity of other canes; therefore it was logical to examine them. This was done and the similarity in the eye, leaf sheath, and leaf of the seedling and of H 146 was immediately evident. They are identical in the ligular process, and the hairing on the scale of the eye occurs in the same places, and their germ pores are the same, bursting being central in both cases. Their wings are the same, being attached in the same manner, and their veining is the same, towards the central germ pore.

With H 109 the seedling has few things in common. A first glance shows the general shape to be the same, but there are marked differences everywhere else.

H 109 has an apical germ pore with veins running longitudinally to it. Its edge is nearly always very irregularly shaped and hooked. Their wings are attached very differently. The hairing of the scale of the eyes is very different and there is no similarity in the ligular process or on the back of the leaf sheath.

These comparisons would place the Lyman seedling as a progeny of H 109 with a marked tendency towards its undoubted male parent H 146.

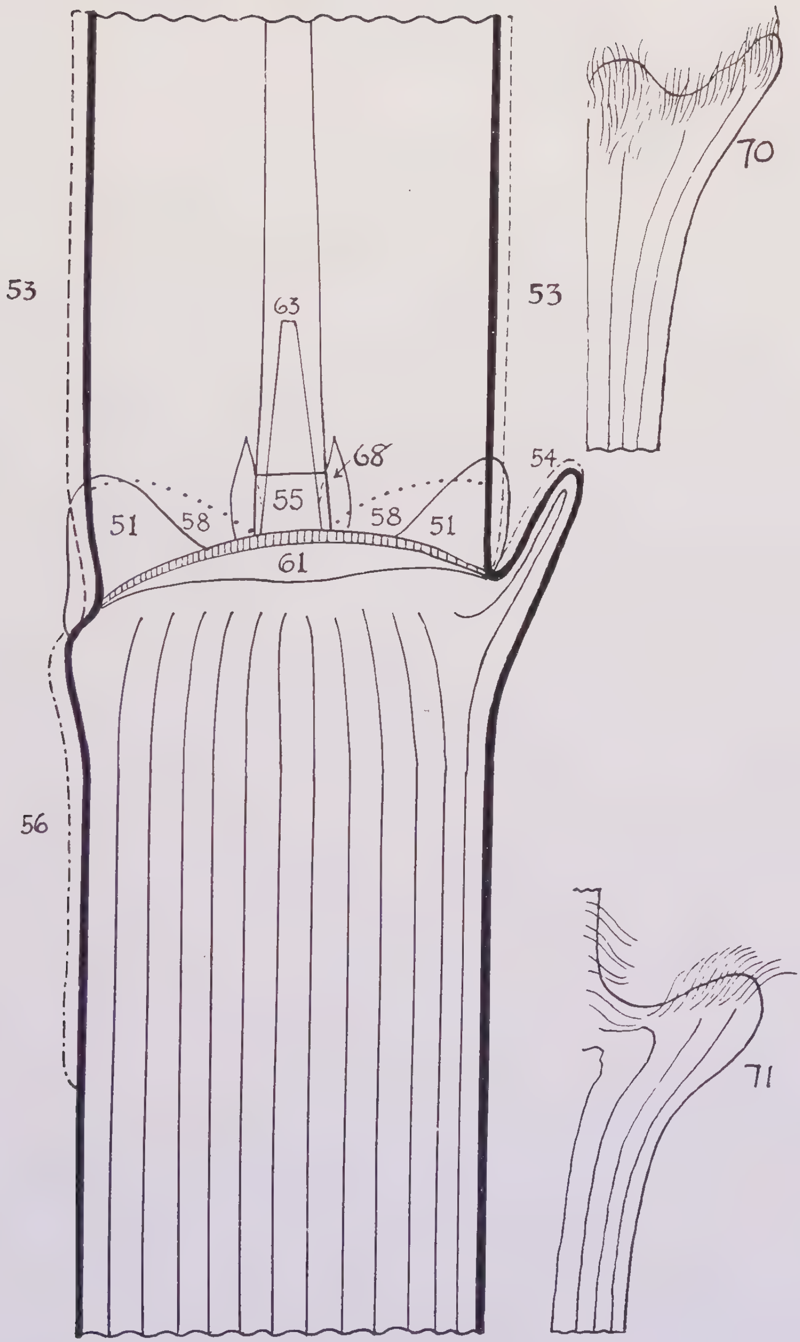


Fig. 5. Plan of sheath and juncture of sheath and blade of the leaf, with hairgroups by numbers, seen from within; also hairgroups 70 and 71 which occur on outside of auricles as shown.

A Comparison of Yellow Caledonia With the Lyman Seedling

Some of the points of dissimilarity between the variety Yellow Caledonia and the Lyman Seedling are found in the appearance, shape and hairing of the eye, the leaf sheath and the ligular process.

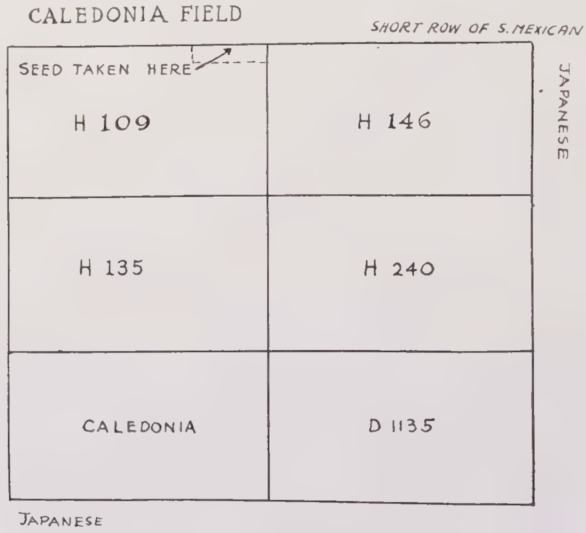


Fig. 6. Plan showing where seed for the Lyman seedling was gathered.

The Eye

First. General appearance of mature eyes.

Second. The total absence in Yellow Caledonia of groups which are prominent in the Lyman seedling and also prominent in H 146. See groups 17, 28, 30, 25, 24.

Third. The presence of groups 13 and 14 in Yellow Caledonia against their absence in the Lyman seedling.

Fourth. The marked differences in groups 11, 2, 10, 18, 19, 4, 5, 15 and 6.

Fifth. Different position of germ pore and method of bursting; also the veining.

Sixth. Wing shape and attachment.

The Leaf Sheath

First. Marked difference in group on back No. 57.

Second. Absence of group 55 on Yellow Caledonia.

Third. Also absence of auricles on Yellow Caledonia.

Lyman Seedling

General Description of Appearance and Growth

Thick stalks, barrel-shaped joints, fair-stooling, joints show tendency to get smaller as stalk grows.

Stalk fairly straight, slightly zigzag, some acari, rind very soft, one stalk broken off a foot from the ground by its own weight. Deep growth cracks.

Some cork cracks.

No eye groove.

Heavy waxing.

Six to seven rows of eyes on root ring.

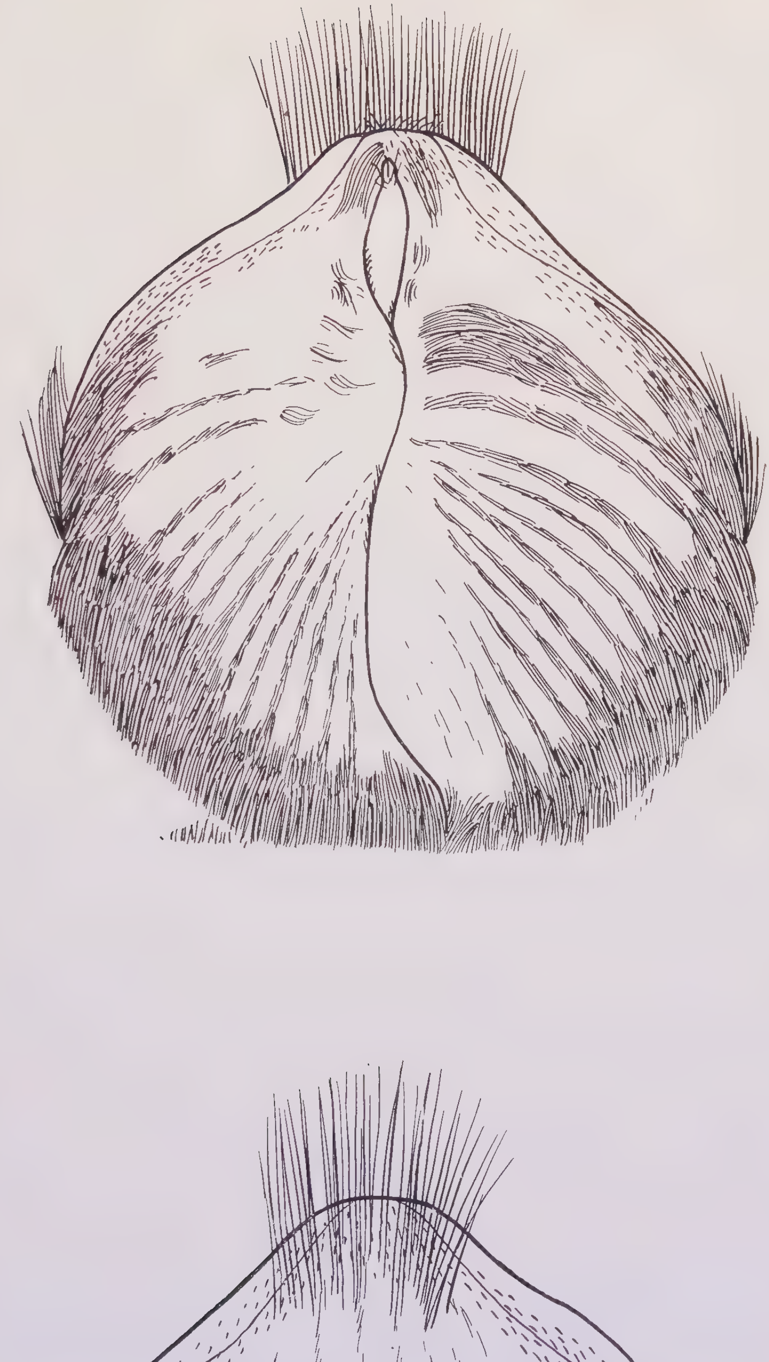


Fig. 7. Lyman Seedling. Front and back of eye, with hairgroups.

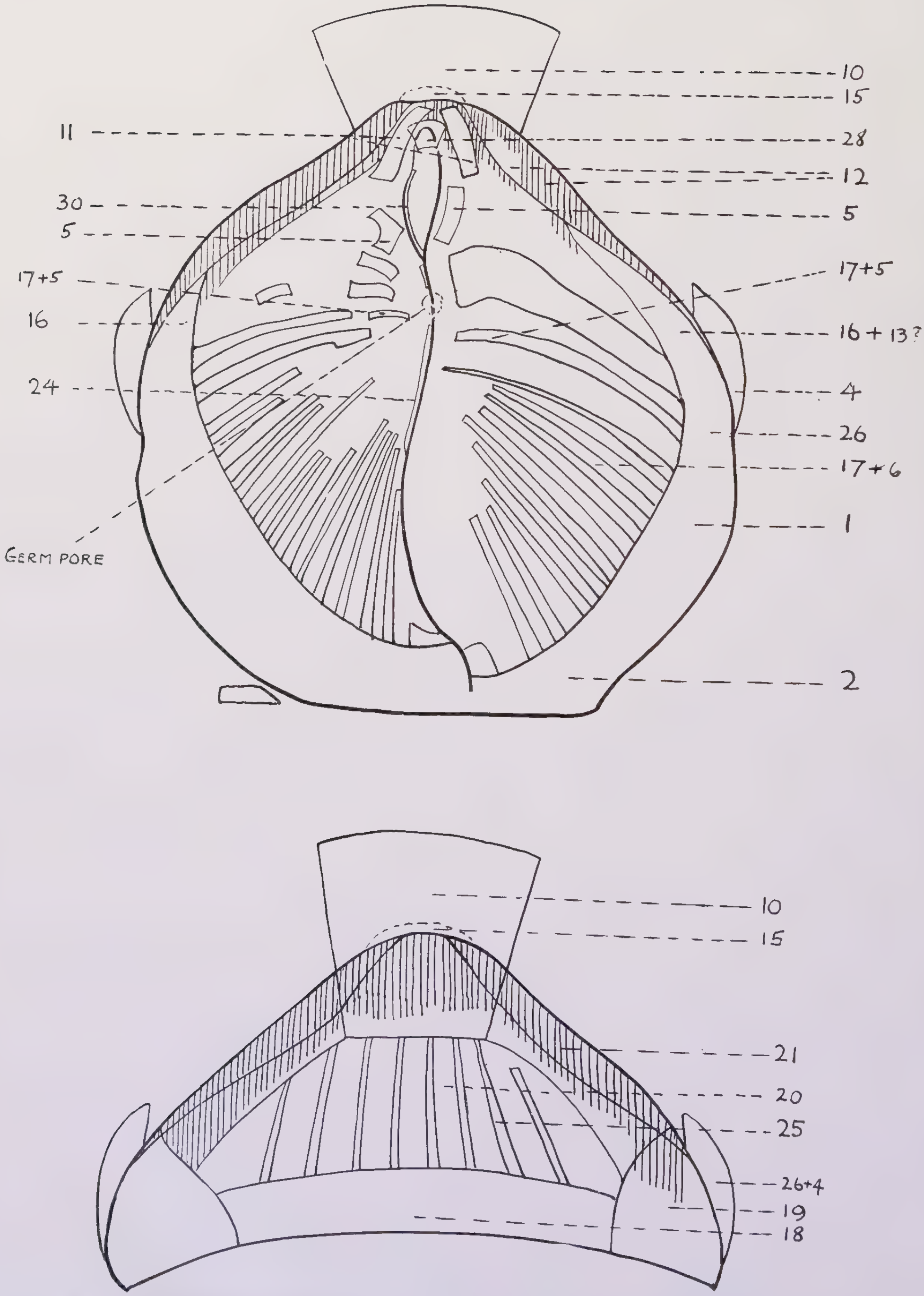
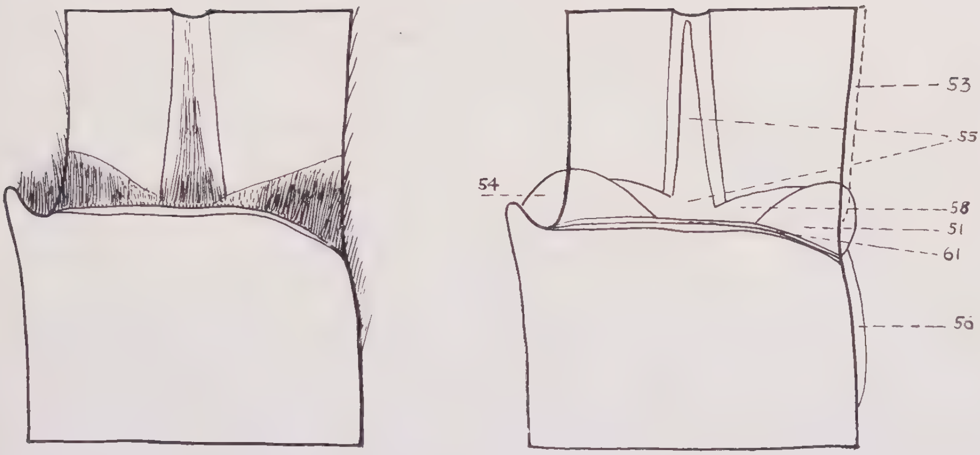


Fig. 8. Lyman Seedling. Plan of front and back of eye with hairgroups by numbers.



A. Lyman Seedling. Juncture of sheath and blade of the leaf, seen from within, with plan showing hairgroups by numbers.

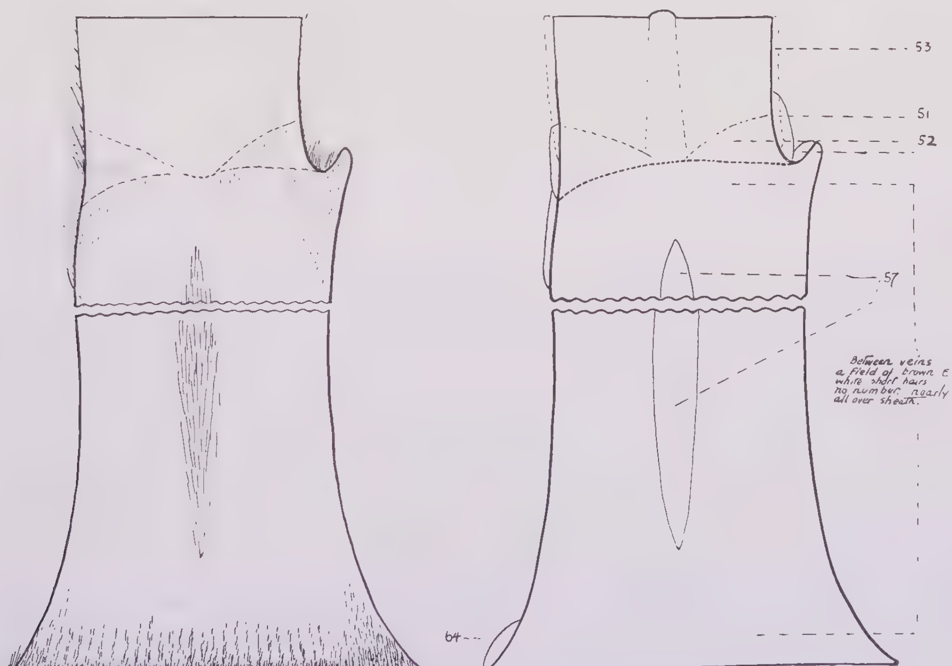


Fig. 9. B. Lyman Seedling. Sheath and juncture of sheath and blade of the leaf, seen from without, with plan showing hairgroups by numbers.

Purplish color mostly, some dark greenish, leaf sheath attached level with node. Eye attached broadly, grows close to leaf sheath scar, wide oval, pointed, slightly flattened tip. Small wings vanishing at top.

Veined to central germ pore.

Fairly flat when young, distinctly humped at maturity, when tip turns up slightly, large in size, edge smooth.

Fig. 10. H 109. Front and back of the eye.

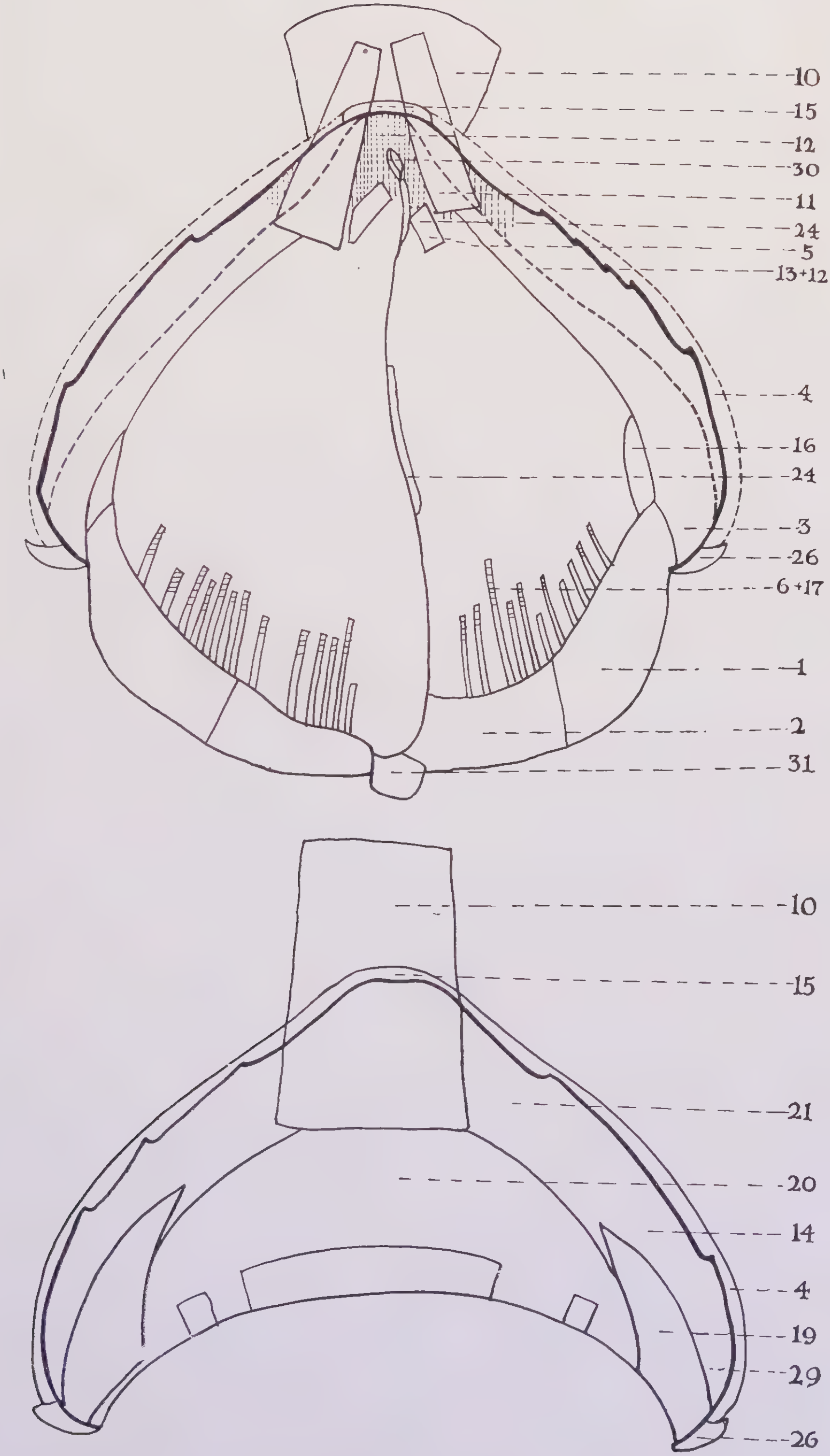
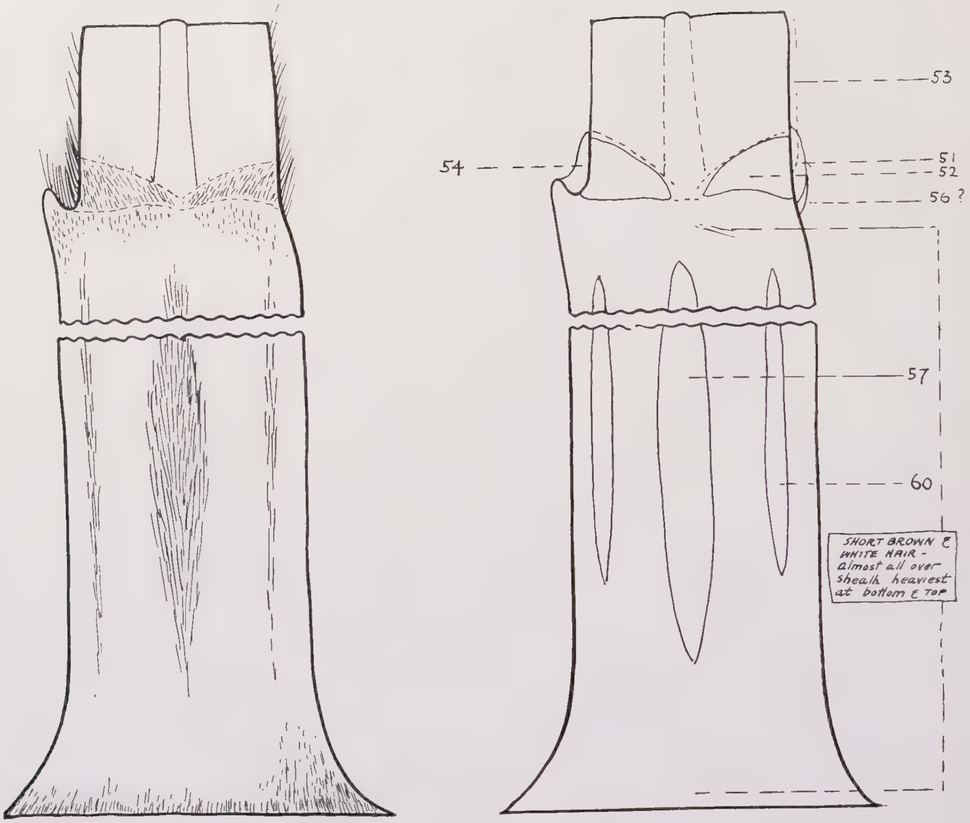


Fig. 11. H 109. Plan of front and back of the eye, with hairgroups by numbers.



A. H 109. Sheath and juncture of sheath and blade of the leaf, with plan showing hairgroups by numbers, seen from without.

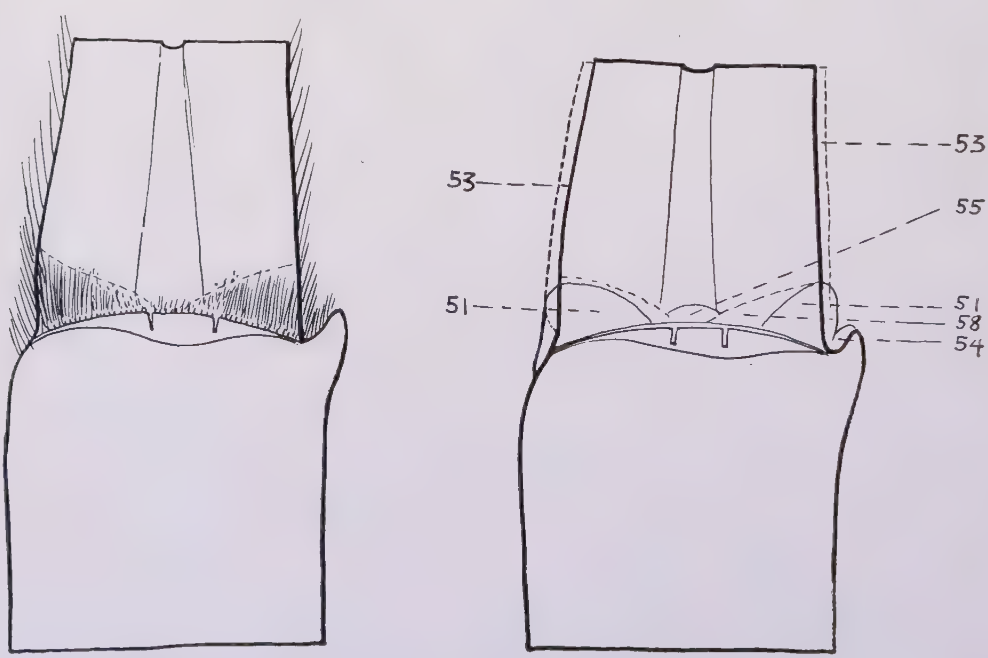


Fig. 12. B. H 109. Juncture of sheath and blade of the leaf with plan showing hairgroups by numbers, seen from within.

H 109

General Description of Appearance and Growth

Large stalks, joints generally long, somewhat barrel-shaped, though generally cylindrical, increasing in size as cane matures, grows fairly straight, slightly zigzag, rind very hard.

Some cork cracks.

Very little signs of eye groove.

Heavy waxing.

Four root eyes average.

Green at times, mostly purplish, leaf sheath attached level with node.

Fig. 13. Front and back of the eye.

Eyes

Eye attached broadly; grows close to leaf sheath scar; elongated when young; at maturity, rounded with pointed tip. Wings start low and go all around eye. Germ pore apical, veined longitudinally. Flat when young, somewhat humped at maturity; fairly large in size, with a notched edge as a marked characteristic.

H 146

General Description of Appearance and Growth

Fairly thick, scanty stooling, gave promise ten years ago but did not stool and ratoon well enough to make it acceptable as a commercial variety.

Grows fairly straight, slightly zigzag, very susceptible to acari, rind hard.

Yellowish, somewhat green, older a little purplish, some cork cracks, no eye groove, medium wax layer, distinct wax ring.

Leaf sheath attached level with the node.

Root ring with 5-4 eye rows.

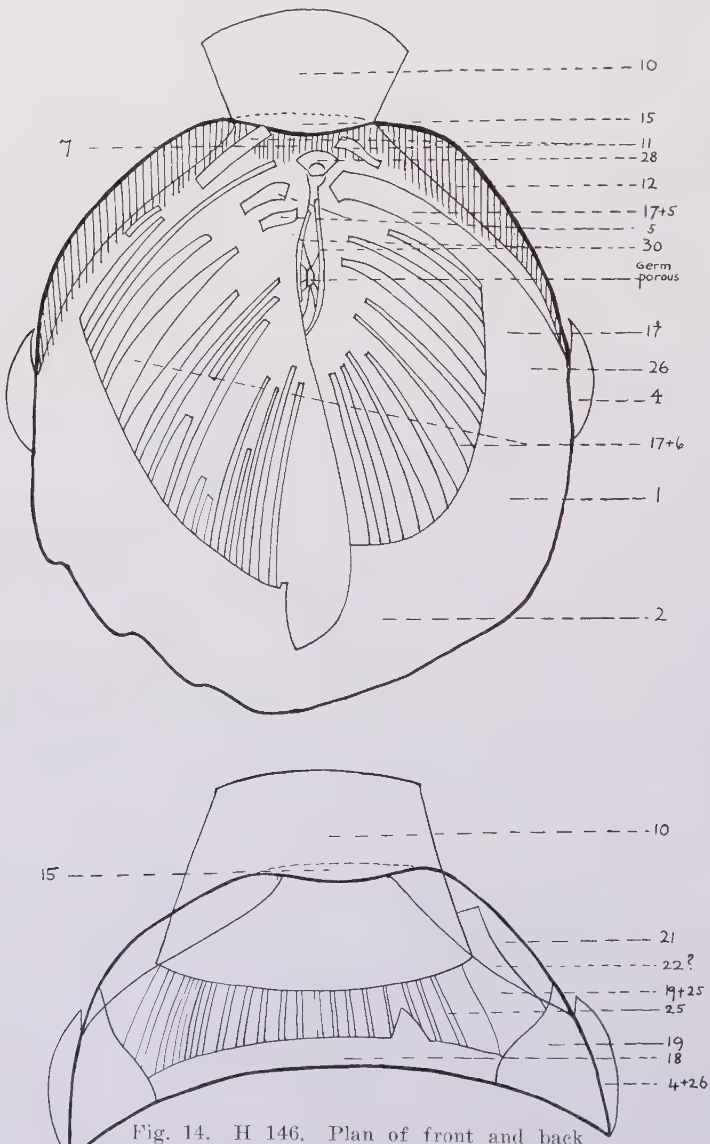
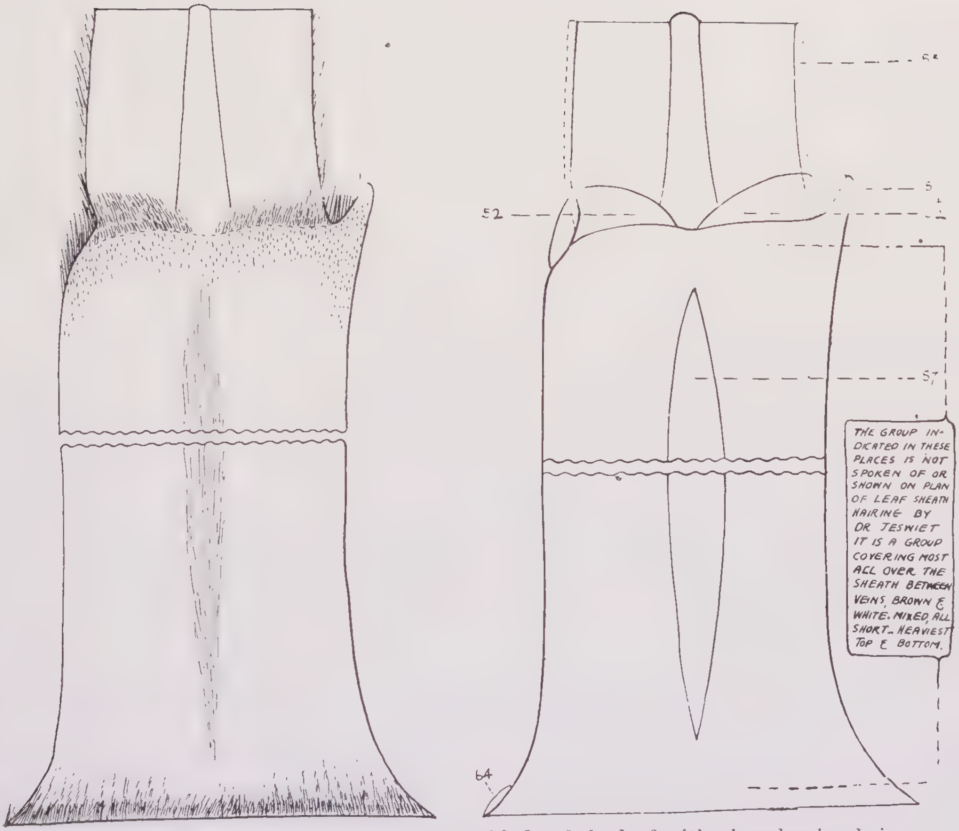


Fig. 14. H 146. Plan of front and back of the eye with hairgroups by numbers.



A. H 146. Sheath and juncture of sheath and blade of the leaf with plan showing hairgroups by numbers. Seen from without.

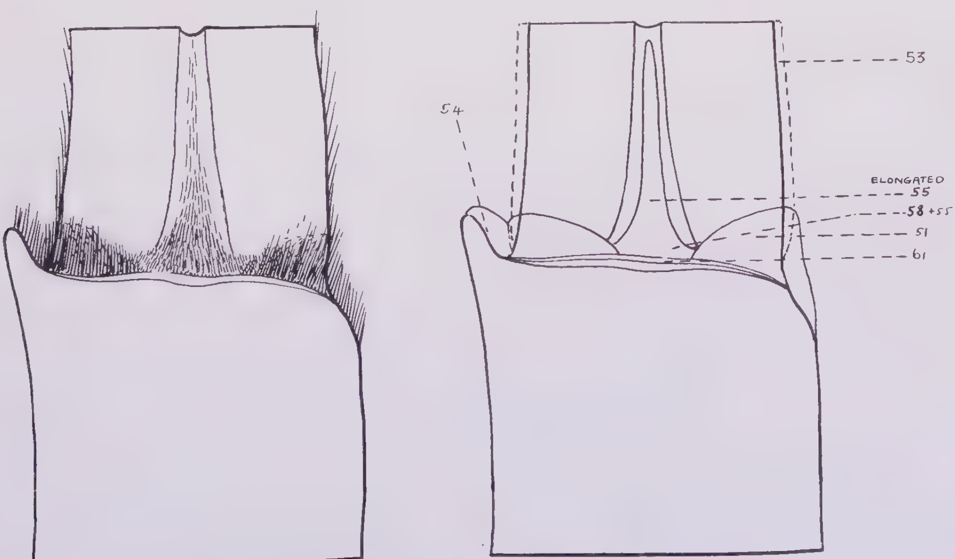


Fig. 15. B. H 146. Juncture of sheath and blade of the leaf with plan showing hairgroups by numbers. Seen from within.

Eyes

Eye attached broadly and set in deep, shape wide oval, flat tip, small wings vanishing at top, veined to central germ pore, slightly humped when young, older distinctly humped, tip turns up very little, medium in size, edge smooth.

Fig. 16. Yellow Caledonia. Front and back of the eye.

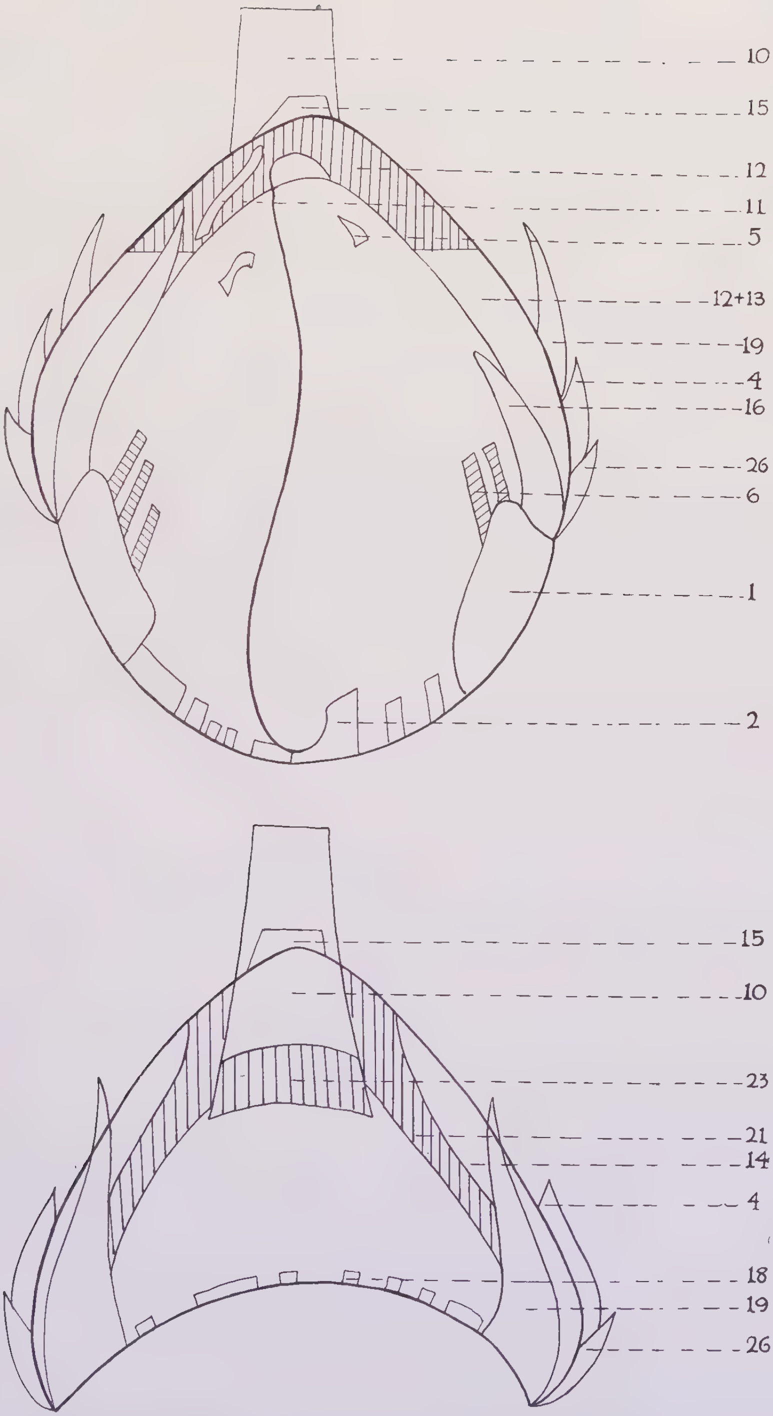
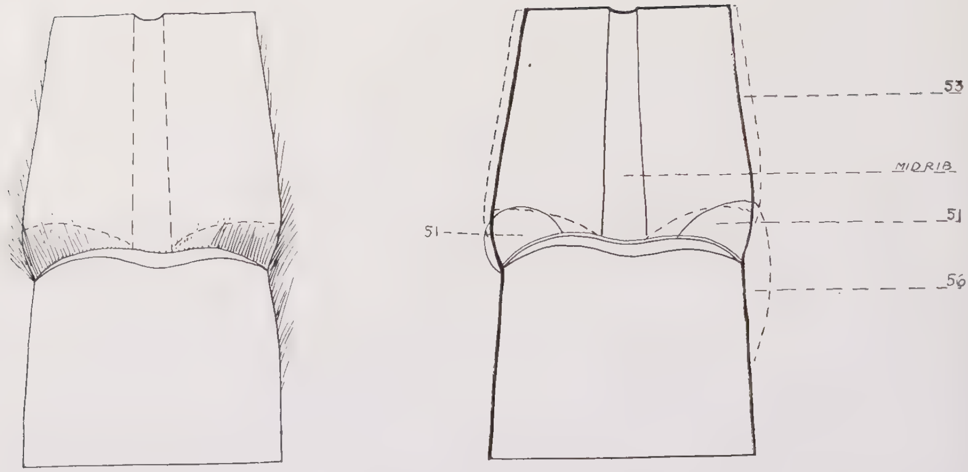


Fig. 17. Yellow Caledonia. Plan of front and back of the eye, with hairgroups by numbers.



A. Yellow Caledonia. Juncture of sheath and blade of the leaf with plan showing hairgroups by numbers. Seen from within.

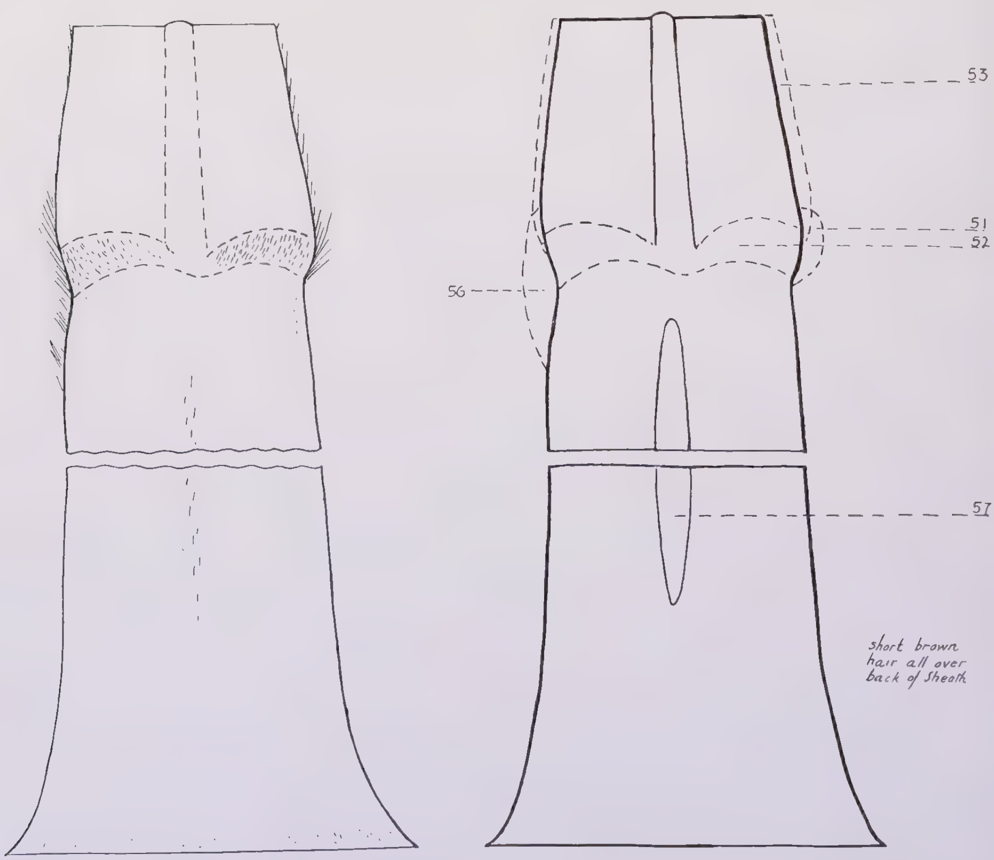


Fig. 18. B. Yellow Caledonia. Sheath and juncture of sheath and blade of the leaf with plan showing hairgroups by numbers. Seen from without.

Yellow Caledonia

General Description of Appearance and Growth

Very tall, heavy, straight, yellow green, later reddish blotches on yellow. Towards maturity brown, yellow and red spots or streaks just above growth ring and many cork cracks.

A very hard cane, leaves broad, very straight, turned over at tip, spotted yellow.

No growth cracks.

Wax layer even and thin.

Wax ring distinct.

Cylindrical internodes, slightly flattened eye side.

Rind fibre uncolored.

Growth ring swollen.

Generally three to four eyes.

Very seldom eye groove.

Eyes

Well developed eyes are egg-round, pointed, narrow winged, strongly arched with uplifted tip, grow tight against stalk, except tip. The wing is narrow, and equal size all round eye.

In the lower joints just above the ground and in young ratoons are eyes of deviating shapes, so-called "coral eyes" entirely or partly locked in a cavity, and with the front side or tip so little developed that one sees the back protruding ahead of the tip.

The Assimilation of Nitrogen by Sugar Cane

Nitrates vs. Ammonia Salts

By W. T. McGeorge

While considerable variation in the nitrogen content of Island sugar lands exists, in general they are high in total nitrogen of low availability. It has been noted on Grove Farm that a plant crop following a fallow will show little or no response to nitrogen applications, but otherwise instances are rare where cane has failed to respond markedly. This applies to virgin as well as cultivated soils. Nitrogen fertilization under the present plantation practice therefore devolves into purely a question of the profitable limit.

Sufficient experimental data have been published to prove the low nitrification or rather a dormant nitrifying power in Hawaiian soils. This is especially true of the acid soils, for example, the Hamakua coast and upland areas on the other islands. In the districts of less rainfall, that is on the irrigated plantations, the soils are less acid, many being alkalin and there is a greater degree of nitrification. As a whole, the cultural methods in vogue are not conducive to the environment productive of high nitrification of the soil nitrogen. In the process of nitrification ammonia represents one stage in the bacterial decomposition of organic forms of nitrogen. In the absence of sufficient aeration or oxygen supply the process is retarded at this point.

While nitrogen as nitrate is best adapted to assimilation by most plants a number of experiments have shown that certain plants will produce a normal growth when supplied with nitrogen in the form of ammonium salts only. For example, of local interest, we may cite the work of Kelley on the assimilation of nitrogen

by the rice plant. In view of the low nitrification in the Island soils Mr. Stewart has suggested a similar study on the assimilation of nitrogen by sugar cane. That is whether ammonium salts can be directly assimilated. In an attempt to throw some light on this question three experiments carried on in sand and water cultures gave the following interesting results:

Experiment 1.

The object of this experiment was to determine the comparative growth of sugar cane in nutrient cultures varying only in forms of nitrogen, namely, from sodium nitrate and ammonium chloride.

Containers. Three-gallon earthenware jars were used. To each of these 20 pounds of pure silica sand, previously sterilized in an autoclave for 2½ hours at 15 pounds pressure, was added. Tubes and funnels were adapted to permit addition of nutrient solution to the bottom of the pot, to permit aeration and the removal of nutrient when desired.

Seed. Three-eye cuttings of H 109 cane, the ends of which had been painted with paraffin and then allowed to stand in 4 per cent formalin for ten minutes. These were planted about one inch below the surface in the sand.

Nutrient. Nutrient cultures of the following composition were prepared.

No. 1 containing nitrogen as nitrate but no ammonia.

190 p.p. mil. Potassium.
172 p.p. mil. Calcium.
52 p.p. mil. Magnesium.
117 p.p. mil. Phosphate (PO_4).
160 p.p. mil. Nitrogen.
202 p.p. mil. Sulphate (SO_4).

The salts used in making the above included potassium nitrate, calcium nitrate, sodium nitrate, monobasic potassium phosphate and magnesium sulphate. This nutrient had a reaction of pH 5.3.

No. 2 containing nitrogen as ammonium and no nitrate.

190 p.p. mil. Potassium.
172 p.p. mil. Calcium.
52 p.p. mil. Magnesium.
117 p.p. mil. Phosphate (PO_4).
160 p.p. mil. Nitrogen.
202 p.p. mil. Sulphate (SO_4).

The salts used in making the above included ammonium chloride, magnesium sulphate, monobasic potassium phosphate, potassium sulphate and calcium carbonate. A trace of iron as citrate was added to both nutrients. The reaction of this nutrient was pH 4.97.

Twelve hundred cc. of nutrient was added to each pot and the surface of the sand painted with a paraffin-vaseline mixture in order to prevent contamination of the ammonia cultures with nitrifying bacteria. The experiment was run in duplicate, that is two pots of each culture. A set of gravity bottles was used for aeration and for drawing off the old nutrient. The pots were aerated twice each week and the nutrient culture was changed once each week, 500 cc. of fresh nutrient being added to replace that removed.

The seed was planted February 28, 1923.

On March 20, tests for ammonia and nitrate were started on the culture medium. These tests showed the ammonium cultures to be still free of nitrate nitrogen but ammonia was present in the nitrate cultures due to insufficient aeration.

On March 25, the shoot from the seed in one of the nitrate pots had penetrated the paraffin-vaseline surface. On April 10, the shoot in the second nitrate pot had penetrated the surface and it was noted that this shoot had developed from a bud on the under side of the seed and hence was slower in reaching the paraffin-vaseline covering. It should be mentioned that while the germination appears to be very slow the weather at that time was not of the best.

On April 6, the surface covering was removed from the ammonium pots sufficient to observe the development of the seed. There was scarcely any root development, while the seed in the nitrate pots possessed a heavy healthy root system reaching almost to the bottom of the pot. In the ammonia cultures the roots were of a dark brown color and the buds gave no appearance of development. The paraffin-vaseline surface was again applied and the experiment continued without disturbance.

Nitrate tests on the nutrient culture from the ammonium pots were made each week up to the termination of the experiment without at any time obtaining a positive test. In view of the delicacy of this phenoldisulphonic acid test for nitrates, this gives absolute assurance of the absence of nitrate in the cultures.

On June 15, practically four months after planting, the experiment was discontinued without any appearance of shoots from the ammonia cultures at this time.

The comparative appearance of the root systems is best illustrated by the accompanying illustration in Plate 1. A brief description of the condition of the plants follows.

Nitrate cultures: These plants had developed a mass of main roots abundantly supplied with root hairs. The main roots shaded in color from a healthy reddish brown to yellow with the root hairs almost white. The length of plant above the surface was 60 inches and of the roots 16 inches.

Ammonium cultures: The seed appeared to be dead in so far as any indication of germination was concerned but was still solid and although quite dark in color there was little or no indication of decay after having been planted four months. One bud had swollen and reached a length of about ¼ inch and another ½ inch. The roots showed some development, but most were dark and stubby. On one seed there were ten roots of measurable length, the longest being 1½ inches, all were black except the tips of three, which had a slight indication of life (a pale yellow color at the tip). There were no root hairs. In the seed from the second ammonium culture pot there were eleven roots of measurable length and all similar to those already described, lacking root hairs.

Experiment 2

In view of the absence of bud germination and extremely faint root development, and in the absence of nitrates and nitrifying bacteria, further attempts to grow with ammonium salts as the only source of nitrogen were made. In this ex-

Plate 1.

periment the seed was not entirely covered, thus allowing some contact with the air. In Experiment 1 the vaseline-paraffin coating was applied to the surface of the sand to prevent the chance entrance of nitrifying bacteria, thus giving assurance of their absence. In Experiment 2 this was omitted in order to give the seed better contact with the air. This experiment included attempts to grow in both water and sand cultures.

1. An eight hundred cc. beaker was placed inside a 1.3-litre beaker, H 109 seed, prepared as previously described, placed on the 800 cc. beaker which acted as a support. Nutrient culture solution No. 2 was added to such a volume as to leave one-half the seed exposed to the air. The nutrient was changed each week and the old solution tested for nitrates. A positive test for nitrate was obtained on the

eighteenth day. At this point the shoots were well developed and growing normally. On account of the appearance of nitrate at this point the experiment was discontinued.

2. In this part of the experiment 1.3-litre beakers were filled with sterilized sand and the seed planted leaving a portion of the surface uncovered. The whole was then saturated with nutrient solution No. 2. Three shoots germinated in one seed and grew to 7, 6 and 22 inches respectively, at which point the leaves began to yellow and soon dried up. Yellowing commenced seven weeks after planting and three weeks later the plant was dead. The duplicate, having only one shoot, retained a normal appearance for a longer time, remaining green two weeks longer, but dying more rapidly after the leaves began to yellow. Tests for nitrate in these sand cultures at numerous intervals gave negative results. The roots were very similar in appearance to the description given in Experiment 1, except that they were slightly longer and further developed.

Experiment 3

In view of the appearance of nitrate in the water cultures in Experiment 2 this experiment was repeated as was also the sand culture for confirmation. The same procedure described in Experiment 2 was followed except that the water and sand cultures were sterilized in the beakers ready for planting and seed planted as soon as cool.

The seed was planted May 2, and on May 16 that in the sand culture had just sprouted while in the water culture the shoot was four inches long and fair

Plate 2.

root development had started. The leaves continued to develop normally until May 9, five weeks after planting, when they were yellowing rapidly. At this time the shoot in the sand culture was 4 inches long while in the water culture they were 8½ and 2 inches. The yellowing always started at the tips, first assuming a reddish color. In the sand culture the plant was dead on June 16, while in the water culture it lived one week longer. The examination of the roots showed the same condition already described under Experiments 1 and 2. Plate 2 illustrates more clearly the appearance of the plants at this time. At no period did the roots have a normal color or appearance. Periodical tests for nitrate during the growth of the cane and at the conclusion of the experimnet were all negative.

Conclusions

While results obtained on such a small scale as here described are mainly indicative, they clearly show the vital role which nitrates play in the growth and development of sugar cane.

It is significant that nitrates function to a great extent as a root stimulant while ammonium salts decidedly inhibit their development.

A Simple Cure for Sereh

In an article recently published—Miss Wilbrink*, botanist of the subdivision Cheribon of the Experiment Station of the Java Sugar Industry, announces the discovery of a cure for the Sereh disease of sugar cane.

Early in their experience with Sereh, the Java planters learned that as a rule cuttings taken from diseased canes gave rise, when planted, to diseased plants.

Miss Wilbrink has now demonstrated that if cuttings from plants having Sereh are immersed for half an hour in water maintained at a temperature of from 52 degrees to 55 degree C., the causative agent of the disease is destroyed and that cuttings so treated will, when planted, give rise to healthy canes.

Miss Wilbrink resorted to the hot water treatment of cuttings in an attempt to differentiate between Sereh and the Gumming disease of Java. The latter disease, she had previously shown to be due to a bacterium which was killed by a temperature of 52 degrees C. In her recent experiments, she found that all cuttings infected with Gumming disease were killed outright by the hot water treatment while cuttings infected with Sereh might survive, but were freed from the disease.

Miss Wilbrink does not recommend this treatment for use on a large scale because the temperature required to kill the Sereh infection is very close to the thermal death point for sugar cane cuttings and invariably a percentage of the cuttings treated will fail to grow. It is, however, applicable on small scale plant-

* Wilbrink, G. Warmwaterbehandeling van stekken als Geneesmiddel tegen de Serehziehte van het Suikerriet. Mededeelingen van het Proefstation voor de Java-Suikerindustrie. Jaargang, 1923, No. 1.

ings and is of especial value to experimenters and cane breeders who have occasion to work with small areas of various varieties and wish to keep them free from Sereh and Gumming disease.

We have, for many years, refrained from importing sugar cane varieties from Java for fear of introducing Sereh into Hawaii. Miss Wilbrink's discovery puts an entirely different complexion on the matter for it places in our hands a simple and effective means of destroying any Sereh infection that might accompany the cuttings which we import. It would, at the same time, afford us certain protection against the Java Gumming disease which would be quite as unwelcome an introduction as Sereh.

During the course of her experiments, Miss Wilbrink tested the value of the hot water treatment as a destroyer of the virus of mosaic of sugar cane and found that it had none. This result is in accord with those obtained by other workers with mosaic diseases for in general it has been found that the virus of a mosaic will survive any temperature survived by the host.

Through the kind assistance of Mr. Duker, we have secured a complete translation of Miss Wilbrink's paper and, in the following paragraphs, we quote the substance of some of her more interesting and important statements:

A Dane, Mr. J. L. Jensen of Kopenhagen, was the first person who employed heat as a cure for plant diseases and demonstrated that wheat-seed could be freed from the spores of Smut by treatment in a warm water bath. Jensen's publications on this subject appeared in 1888. These investigations attracted general attention in the scientific world but found little approval at first, although those who carefully checked up Jensen's work had to admit that he was right. Although Jensen himself concluded that his method was too elaborate for practical use and recommended a treatment with chemical disinfectants, still the warm water treatment was successfully introduced to the farmers in Denmark years after by van Ravn and Mortensen. In recent years, there has been a rather extended application of heat as a cure in the flower bulb industry for the growers strive to free their bulbs from nematodes either by means of heated air or a warm water bath.

In the first years of the appearance of the Sereh disease they not only tried to cure the Sereh-diseased cuttings by means of chemical disinfectants such as corrosive sublimate, copper sulfate, potassium permanganate, zinc-sulfate, chloride of lime, molasses and bromide water, but warm water baths were also tried at that time. As far back as 1889, we find that Mr. J. Sayers at Gemoe, perhaps as a consequence of Jensen's investigation, suggested experiments with warm water treatment of cane cuttings as a cure for Sereh, and particulars were published in a pamphlet issued that year.

From this pamphlet as well as from opinions of Kramers and Kobus in the Communications of the Experiment Station, East Java, we understand that Sayers recommended a heating of the cane cuttings during 10 minutes to 50 degrees Centigrade.

As a consequence of these suggestions, Kobus made some experiments in 1889 with warm water treatment of Sereh-diseased cane. Although he mentions that cane cuttings can stand heating one hour in water of 50-52 degrees Centigrade, he did not go higher in his experiments than 50 degrees C., which temperature he kept up for one hour.

The seed thus treated gave a little higher yield than the untreated, but whether or not the percentage of Sereh was reduced by the warm water treatment is not mentioned.

Further experiments were not made by Kobus because he considered the method too cumbersome for practical purposes and in more recent literature we find no further mention of a warm water treatment.

The discontinuation of experiments may also have been caused by the fact that in 1891, Dr. Janse, botanist of the National Botanical garden, published investigations by which he claimed to have demonstrated that Sereh was caused by a bacterium which could stand the temperature of boiling water. At first the conclusions of Janse were accepted, for even so prudent a research worker as Dr. Valeton was thrown off the track and as

long as the impression existed that the Sereh parasite could stand the boiling temperature all hopes of curing Sereh-diseased cuttings by a warm water treatment were naturally abandoned, because the cuttings themselves would surely not be able to withstand so high a temperature.

By the time that it became evident that the contention of Janse was a mistake caused by an incorrect method of isolation, the growing of mountain-seed had demonstrated its great effectiveness in the fight against Sereh, and because the cane remained healthy in the cooler regions, the thought of heat as a cure was given up.

We took it up again when we looked for a method by which the difference between gum disease and Sereh could be demonstrated. A few years ago, the opinion existed that Sereh was nothing more nor less than a chronic form of gum disease and that, therefore, both diseases had the same cause.

Our investigation of gum disease showed this conclusion to be erroneous but even after our publication, the opinion that there was no real difference between the two diseases continued to exist and this we considered undesirable. Therefore, we looked for a method by which we could demonstrate the difference between Sereh and gum disease in such a manner as would be accepted by everyone. The cause of the gum disease is a bacterium which dies at a temperature of about 52 degrees Centigrade.

In a treatise by Dr. E. van Slogteren, we find that the disease of the hyacinths, a disease closely related to gum disease, can be cured with a warm water treatment and this indicated to us the possibility of thus killing the bacteria of the gum disease in the cuttings.

As far as the Sereh disease is concerned, we began more and more to believe in the theory of Prof. Quanjer that this disease was bound to be closely related to the curl-disease of the sugar-beets and the leaf-roll disease of the potato, all of which come close to the mosaic diseases.

The infectious matter of the mosaic diseases proved to be able to withstand high temperatures. Therefore, it appeared to us probable that Sereh-diseased cuttings could find no cure by the application of a warm water bath, whereas it must be possible to kill the infectious matter of the gum disease by such a treatment.

Our first experiments were made during the planting time in 1921. As up to that time the observations by Kobus on warm water treatment of cane cuttings had escaped our attention, we determined first, by preliminary tests, how much heat the cane cuttings could stand. We used, therefore, top seed of E. K. 28 and because this cane also proved to be a resistant variety on this point, somewhat too favorable results were obtained. For instance, no detrimental influence in germination was noticed by heating to 52 at 55 degrees Centigrade for half an hour, a temperature as we found later which most varieties cannot stand.

In our first experiments with gum-diseased and Sereh-diseased cane, which were made on the varieties Black Cheribon and White Preanger, we applied such high temperatures as proved to be rather harmful to the germinating power, but which gave very definite results. And not only did they prove to be definite but a great surprise as well. Of the Black Cheribon, we had at our disposal both gum-diseased and Sereh-diseased cane, but of the White Preanger we had Sereh-diseased cane only.

The gum-diseased cuttings of the Black Cheribon proved to withstand a warm water treatment very poorly. The germination here is slow anyway and by a warm water bath it was entirely destroyed. This result was always corroborated in later tests wherein the temperature did not exceed 52 degrees Centigrade. The chances, therefore, are small to cure gum-diseased cuttings by a warm water treatment. Gum-diseased cane apparently dies off at a lower temperature than the healthy material and it might, therefore, be possible to thus separate the plant material, but because I did not have a sufficient quantity of gum-diseased cane at my disposal, I have not been able to settle this point.

The experience with gum-diseased cane checks with the results obtained when submitting yellow-diseased hyacinths to a warm water treatment and not this, but the behavior of the Sereh-diseased cane was the real surprise.

Of the Black Cheribon the plant material consisted of top-seed and water-soaked seed of Sereh-diseased crop cane. Warm water treatments at from 52-55 degrees were tried for half an hour and for fifteen minutes, whereas a control plot of untreated seed was also planted.

The germination, which was poor anyhow for this seed, seemed to have suffered considerably, but of each kind a number of plants survived and it was extremely interesting to watch the difference in development. The seed, which was heated for half an hour, produced well growing plants with beautiful dark green leaves; the seed which was treated fifteen minutes produced somewhat less regular plants, whereas the untreated seed produced mostly Sereh-diseased plants with yellow-tinted leaves.

The experiment was harvested on February 25, 1922, and every stalk in every stool was analyzed for Sereh with the results as noted in the table, a stool being considered as Sereh diseased when one stick only showed signs of it.

EXPERIMENT 1A.

Cane variety: Black Cheribon.

Seed: Top seed and water-soaked, body-seed of Sereh-diseased crop cane on experimental field.

Treatment	Number of Cuttings Planted 7/23–1921	Number of Cuttings Germinated 9/6–1921	Harvested 2/25–1922 No. of Stools Healthy	No. of Stools Diseased	No. of Sticks Healthy	No. of Sticks Diseased
A. Heated for 30′ in water from 52-55 deg. C.	24	9	9	0	68	0
B. Heated for 15′ in water from 52-55 deg. C.	24	13	9	4	68	22
C. Not heated	24	17	5	12	25	94

The result of this investigation was, therefore, in accord with the observation made on the standing cane. The seed heated for half an hour produced healthy plants only; the seed treated 15 minutes produced largely healthy plants and the non-treated seed gave largely badly affected cane.

In order now to find if the plants considered as cured really remained healthy the seed from the Series A was planted again. Part of the cuttings were again submitted to a warm water treatment, but as may be seen from Experiment 1B, the untreated cuttings produced healthy cane with only one exception and of this stool only one stick was diseased.

EXPERIMENT 1B.

Cane variety: Black Cheribon.

Seed variety: 1st and 2nd seed from Series A, Experiment 1a.

Treatment	Number of Cuttings Planted 2/28–1922	Number of Cuttings Germinated 3/17–1922	Harvested 8/1–1922 No. of Stools Healthy	No. of Stools Diseased	No. of Sticks Healthy	No. of Sticks Diseased
Aa. Heated for 30′ in water of 45-50 deg. C. thereafter 30′ in water of 50-53 deg. C.	50	28	28	0	66	0
Ab. Heated for 30′ in water from 45-50 deg. C. thereafter 30′ in water from 50-52 deg. C.	50	38	38	0	92	0
Ac. Not heated	50	49	48	1	137	1

The warm water bath, therefore, had actually freed the cane from Sereh.

Miss Wilbrink gives the details of experiments with other varieties of cane, all of which corroborate the results obtained with Black Cheribon.

From the evidence presented, we may safely conclude that she has discovered a simple but sure method of ridding cane cuttings of the agent which causes Sereh

H. L. L.

Selection of Seedlings

On the opposite page, we present a sketch giving an outline of the methods we are now following in our seedling work.

Field Test 1 is the first planting in the field, from the nursery pots, of the seedlings germinated from the tassels. In Field Test 1, each stool represents a different variety, in that each stool is from a single cane seed, and not a cutting. We have never yet raised two seedlings which were alike in all respects. When from one to two years old, Field Test 1 is selected and the selected canes are planted to Field Test 2. In this selection we discard from 50 to 90% of the seedlings, depending on their quality and also on the area of land available for planting. Field Test 2 is selected and planted to Field Test 3 in the same way. Each "Field Test" represents a selection. Field Test 4 indicates that that series of seedlings have been selected four times.

Seedlings remaining in Field Test 4 are of good promise and are then planted into regular field experiments against standard canes.

Ratooning a Field Test does not change its number. If Field Test 2 plant is ratooned it becomes Field Test 2, first ratoons, etc.

In order to further identify the different seedlings, we add to the Field Test number the year of propagation. Field Test 1, 1923 propagation, means the first field planting of seedlings raised from tassels collected in the 1922-23 tassel season.

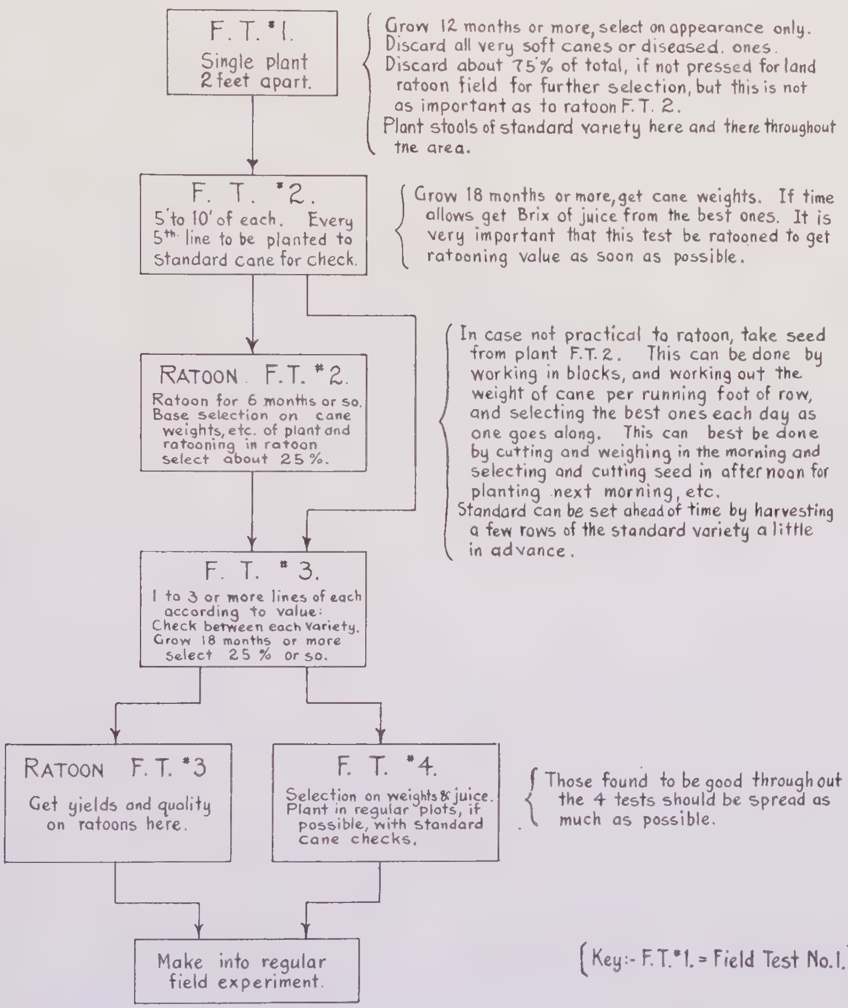
In Field Test 1, the individual seedlings of one parentage are planted together, that is, all H 109 together, all Lahainas, etc., and are given temporary field numbers. It is very important to keep this numbering straight, as in the selection of seedlings it is essential to be able to trace the individuals back from plant to ratoon. To be good, a seedling *must* be a good ratooner in addition to producing a good crop of plant cane.

As soon as a seedling is deemed good enough to be spread and tested against the standard canes, it is then given a permanent number.

We have recently adopted the policy of naming a seedling after the place or plantation where it is first developed into a promising cane. So, we now have Wailuku seedlings 1 to 53, Makaweli 1 to 4, Honokaa 1, and a number of Tip seedlings developed at Kohala Sugar Company known as Kohala 75, 86, 117, 202, and a number of others.

J. A. V.

OUTLINE OF SEEDLING SELECTION



In planting, use a "3-eye" seed piece from which two eyes are gouged out. Let the best eye be kept and cut the seed so that the best eye is in the middle. Plant one eye per foot. In wireworm country, or where general conditions are poor, use twice the amount given above. Plant 2 or 3 extra seed per each 10 feet to replace any misses. When the stand is full, destroy extra shoots, leaving one per running foot.

Use good seed, and of the kind which experience has shown is best in that district. The percent to be selected or discarded as indicated above is more or less nominal and will vary within very large limits depending upon conditions.

J. A. V. May 1923

Kauai Seedling Propagation

By Olen C. Markwell

In order to give the reader a simple perspective of the progress of seedling work on Kauai, the accompanying chart was made, showing chronologically the work from 1917 as started by R. S. Thurston, continuing through the years 1920-'21-'22 by J. H. Midkiff, and carried on in '22 and '23 by the writer. It is my desire to show clearly just where each propagation stands today and to make a reasonable forecast of what the results will be.

I find that since 1917, 47,923 seedling cane plants have been set to Field Tests No. 1. From these, 6,963 were found to be of promise and were planted to Field Test No. 2. Unfortunately, 797 seedlings of Field Test No. 2 were lost. At McBryde Sugar Company, Field Test No. 2, 1917 propagation, made up of 303 seedlings, through misunderstanding was plowed up; Field Test No. 2, 1919-'20 propagation at Lihue Plantation Company was also plowed out.

There are four Field Tests No. 3, in which are found 424 seedlings. Some of these seedlings have gone into Field Test No. 4, so that today the Hawaiian Sugar Company has 35 seedlings and McBryde Sugar Company 108 seedlings in Field Test No. 4, plant crop.

The question arises as to the standard of selection used. From the total of the various field tests we have the following:

Field Test Number	Total Seedlings	% Selection For Subsequent Field Test
1	41,096*	16.9
2	6,963	6.1
3	424	17.9
4	76 & 77	

In Field Test No. 4 the figure 76 was used, for 76 seedlings came through Field Test No. 3, while 77 seedlings were taken from Field Test No. 1, old ratoons.

With the exception of some seedlings at Makee Sugar Company and a few at Koloa and Kilauea plantations, the Hawaiian Sugar Company and McBryde Sugar Company hold the most promising ones. They not only hold the bulk and promise of Kauai seedlings, but they have carried them further, consequently are ready for a more comprehensive study than heretofore has been given them.

Mr. Poole, Selectionist for the Hawaiian Sugar Company and McBryde Sugar Company, is now at work in this area.

In the beginning, it was made quite clear to me that Kauai was reaching out for a good "ratooner". To find and develop such a cane, it is obvious that one must work for a number of years, ratooning the seedling areas and basing the selections on the ratooning qualities of the different seedlings.

Even in these advanced field tests it is not possible to say that any one of the good canes is uniformly superior. If there is any one quality that proves a

* This does not include the areas which were plowed out.

stumbling block and often a bitter disappointment to the selectionist of seedling canes, it is uniformity. Whether some of the seedlings are actually sporting at a tremendous rate or if the lack of stability is due to some other cause, not inherent, I cannot say. While I have no data to substantiate the statement, I do know that the individuals of the seedlings vary widely.

Hawaiian Sugar Company's Seedlings

Field Test No. 4, 1918 propagation, Hawaiian Sugar Company, is a plant crop containing 35 seedlings, planted September, 1922. The seed was cut from Field Test No. 2 of that prapagation, first ratoons, after a careful study of data from the harvest of Field Test No. 3, plant at that time. In addition to the mill data, a thorough observation of the Field Test No. 2 revealed seven canes of strong ratooning power. These were also planted, therefore we have:

Propagation	Plantation	F. T. No. 2	F. T. No. 3	F. T. No. 4
1918	Hawaiian Sugar Co.	2nd ratoon	1st ratoon	Plant

The time is at hand for a detailed study and thorough checking up of the ratooning behavior of all the seedlings in Field Test No. 4 and at the same time to bring under observation good ratooners which have been overlooked or for some unknown cause have come to the front.

Mr. Poole has made a cursory study of the 1918 propagation, but at this time he has nothing to give in the way of an accurate checking up.

While the mill data is a very desirable guide in selecting for planting to advanced field tests such data is far from infallible, e. g. No. 90 (now Makaweli No. 1), the "whale" of the entire propagation giving 16 tons of sugar per acre when weighed and sampled in Field Test No. 3, plant, is a poor ratooner in first ratoons there, looks fairly well in plant Field Test No. 4, and a fair ratooner in second ratoons in Field Test No. 2. Taken all in all the "pick" of Kauai seedlings are to be found in the Hawaiian Sugar Company's fields.

In the 1919 propagation, the Field Test No. 2 lies alongside of Field Test No. 3 of 1918 propagation and compares very favorably with it. There are 632 seedlings in this field test, many of them promising. Mr. Poole is making observations on them. Selecting and planting should be done here soon.

During June, 1923, the 1920 propagation, consisting of 403 seedlings, was weighed and sampled. Not much importance had been attached to these seedlings, although they had been observed, but the harvesting results showed that many of them were equal to or better than the H 109 checks. After a study of the mill data, it was found that 95 of them were good. The ratooning quality of these will be noted with interest.

While the 1921 propagation, containing 17 seedlings, has been carried to Field Test No. 2, nothing is outstanding.

One might question the desirability of Badila seedlings at Makaweli. However, the 1922 propagation contained 40 seedlings of that parentage. Thirteen of these looked promising and were planted along with 33 seedlings of other parentages to Field Test No. 2, 1922 propagation. They are doing nicely.

McBryde Sugar Company's Seedlings

Field Test No. 4, 1918 propagation, is too young to have its value intelligently estimated. Seventy-six of its 153 seedlings were taken from first ratoons Field Test No. 3, while 77 of them were taken from "old ratoons" Field Test No. 1.

Field Test No. 2, 1919 propagation, second ratoons, contains 237 seedlings. These ratoons have not yet been thoroughly checked, so one cannot be sure as to how many should be carried to Field Test No. 3, but the mill data show 15 to 18% as promising.

You will note that here we are to select from second ratoons Field Test No. 2 for the planting of Field Test No. 3. This is a bit unusual, but since we are seeking a mauka cane which is a good ratooner, we may discover a short cut by eliminating the bad ones here rather than Field Test No. 3. It is a question whether we are not doing too much work on plant cane while looking for ratooners. I know the object is to find "the cane", nevertheless it creates a favorable impression to have the tons-of-sugar-per-acre for the seedling area as good as that of the crop cane.

Mr. Alexander, manager of McBryde Sugar Company, has desired that the work in seedlings be under mauka conditions. He said, "We must have a mauka cane," consequently these seedlings were put to a severe test. Scarcity of labor, low temperature, and the constant encroachment of weeds have given the largest and most promising propagation a fight for its life. Field Test No. 2, 1920 propagation, has suffered. When this field test was first planted there was a shortage of labor and water, so the seedlings necessarily were neglected.

In December, 1922, and January, 1923, the 2,566 seedlings and their checks were weighed and more than 500 samples taken. A study of the mill data placed 246 as equal to or better than the check D 1135. One should not anticipate good ratoons from all of these 246, consequently Field Test No. 3 may be less than that number.

I find that Field Test No. 2, 1920 propagation, was planted in three installments, in reality three selections from Field Test No. 1.

Mr. J. H. Midkiff said that he and one helper, Mr. King, I believe, went over Field Test No. 1 selecting about 700 seedlings, later the field test was re-selected and between 1,000 and 1,200 were taken, and at a later date the field test was again reselected and 500 additional ones taken.

This first selection was planted to 700 approximately (see blue print No. 118), the second selection to about 1,900 (see blue print No. 119) and the third selection planted the remainder.

In weighing and sampling this Field Test No. 2 fully seventy-five percent of the desirable canes fell within this first selection, the second selection was much poorer, and the third was almost worthless. One cannot say positively that this wide difference was due to higher standard of selection, for soil variation may have entered, but I do think that to selection a part of this difference was due.*

J. A. V.

* Results of a similar nature have been obtained in Honolulu in the 1918 propagation. The 8900 series comes from about 104 seedlings which were considered the most promising on the first selection. The remaining couple of thousand 1918 O. P. seedlings have but 3 or 4 promising canes left.

The 1917 propagation met with disaster. A misunderstanding led to the plowing up of this field test area early in 1922. Since it did not receive a thorough plowing, it may be possible to find among the H 109 planted there any outstanding seedlings which may have survived. Perhaps it would be well to go thru this area and look for such late in August or early in September of this year.

Koloa Sugar Company

Koloa Sugar Company 1920 propagation has been planted under makai and mauka conditions. Even though a cane may not prove desirable makai owing to its failure to give a maximum response to optimum conditions—soil, temperature, light, water, and fertilizers—it may prove a profitable one for mauka conditions. A cane which is vigorous and ratoons well is always desirable. If any cane possesses these qualities, it is worth while to try it mauka.

Of the 1920 propagation there are 21 seedlings of fair promise. The Wailuku seedlings and various other seedlings sent over from Honolulu are doing nicely.

Makee Sugar Company

Of the 1920 propagation Makee has 840 seedlings of first ratoons Field Test No. 2. During February, 1923, these seedlings were weighed and sampled. Mill data leads us to believe that 46 of them are equal to or better than the check H 109.

Lihue Plantation Company

Last November, Mr. Kutsunai and I went through the area of the 1919-1920 propagations, Lihue Plantation Company, and flagged the seedlings which looked promising. This seedling area, as a whole, looked poor so it was plowed up by the plantation in March, 1923.

Kilauea Sugar Plantation Company

Kilauea Sugar Plantation Company's seedlings consist of 17 Kauai propagation 1919, 1913, '14, '15 and '17 Oahu propagation, and a number of Badila seedlings. Of the seedlings at Kilauea the ones of Badila parentage are most promising. It might be well to have more seedlings of Badila parentage under the mauka conditions of Kauai.

Grove Farm Plantation Company, Ltd.

The 1918 and 1919 propagation have shown no seedling of promise. Of the 1918 propagation none have gone to Field Test No. 3. However, of the 1919 propagation two were planted, but they are not unusual. I notice that many of the seedlings had yellow stripe, which was taken care of. As this field test is active the ratoons will be observed.

General

Computed on a basis of total seedlings in Field Test No. 2 of all propagations on Kauai, there are at present, as the data at hand show, 6,963 seedlings. These are distributed as follows:

Plantation	Seedlings in F. T. No. 2	Percent of Total Seedlings
McBryde Sugar Co.	4140	59.6
Hawaiian Sugar Co.	1682	25.5
All other	1141	14.9

Because the McBryde seedlings are grown under adverse conditions, the total number to reach Field Test No. 4 will be relatively small. Since "all other" plantations on Kauai have only 14.9% of the total Field Test No. 2 seedlings, obviously they need more.

If these are to be propagated here, the work of planting, observing, and selecting them could be carried on more advantageously if one plantation should take one year's propagation, e. g. Grove Farm Company, Ltd., 1924; Lihue Plantation Company, 1925, etc.

A difficult problem to meet is the numerous propagations on the various plantations. Since a luna doesn't think of seedlings in terms of propagation years, the above condition frequently gives rise to misunderstanding which results in confusion in seedling work. The average luna has all he can do to look after the crop cane, which is of immediate importance.

In all the seedling work on Kauai, there has been a sincere spirit of cooperation expressed by the many helpful suggestions and personal observations on the part of managers and lunas, without which progress in seedling work would be seriously impaired.

Summary

1. Total Field Test No. 2 seedlings all propagations (Kauai) is 6,963. McBryde Sugar Company has 59.6% of these; Hawaiian Sugar Company 25.5%; other plantations 14.9%.

2. Advanced seedlings are:

Plantation	Propagation	F. T. No. 1	F. T. No. 2 2nd ratoon	F. T. No. 3 1st ratoon	F. T. No. 4 Plant
Hawaiian Sugar Co.......	1918	0	594	113	35
McBryde	1918	0	1337	281	31–37

3. At present, considerable time should be given to canes of the above field tests in order to check ratooning quality as shown in Field Tests Nos. 2 and 3. More stress should be put upon descriptive work of these canes.

4. Field Test No. 2, 1920 propagation, McBryde indicates that a fairly close selection is desirable.

5. In the future it might be advantageous to allot to the various plantations propagations by years.

KAUAI SEEDLINGS 1923.

Propagation Year	Plantation	No. of Active F. T.'s	F. T. No. 1 Active	F. T. No. 1 No. of Seedlings	F. T. No. 2 No. of Seedlings	F. T. No. 2 Ratoon	F. T. No. 3 No. of Seedlings	F. T. No. 3 Ratoon	F. T. No. 4 No. of Seedlings	F. T. No. 4 Ratoon	Remarks
1917	McBryde Sugar Co...	1	No	908	303	.....	...	.....	.....	.....	Thru a misunderstanding, this entire field test was plowed out early in 1922.
1918	McBryde Sugar Co...	3	No	3248	1337	2	281	1st	31–37	Plant	Promising.
1918	Hawaiian Sugar Co..	3	No	4200	594	2	113	1st	35	Plant	Promising.
1918	Grove Farm Co., Ltd.	1	No	1000	....	.....	9	1st	.....	.....	Not promising.
1919	McBryde Sugar Co...	1	No	2592	237	1	...	.....	.....	.....	Plantation cut for replant seed last July.
1919	Hawaiian Sugar Co..	1	No	4703	632	1	...	.....	.....	.....	
1919	Lihue Plantation Co..	..	No	3895	231	1	...	.....	.....	.....	Plantation plowed out this field test—Seedlings were not very promising.
1919	Grove Farm Co., Ltd..	1	No	1009	93	2	...	.....	.....	.....	Not promising—will watch ratoons.
1919	Kilauea Sug. Pl. Co..	1	No	650	17	.....	17	1st	.....	.....	Only fair.
1920	McBryde Sugar Co...	1	No	15686	2566	1st	...	.....	.....	.....	Weighed and sampled in January, 1923.
1920	Hawaiian Sugar Co..	1	No	2221	403	1st	...	.....	.....	.....	Weighed and sampled in June, 1923.
1920	Koloa Sugar Co......	3	Yes	1582	181	1st	21	.....	10	Plant	Promising
1920	Lihue Plantation Co..	..	No	1124	263	.....	...	.....	.....	.....	Plowed up by Plantation.
1920	Makee Sugar Co.....	1	No	3794	840	1st	...	.....	.....	.....	Weighed and sampled in February, 1923. Look good.
1921	Hawaiian Sugar Co..	2	Yes	148	17	Plant	...	.....	.....	.....	Only fair.
1922	Hawaiian Sugar Co..	2	Yes	263	36	Plant	...	.....	.....	.....	Promising as young canes.
	Grand Total			47023	7750						
	Less seedlings plowed up.............			5927	797						
	Total			41096	6953		424		153		

Spend to Save*

Many power plants will not stand even a casual inspection. They operate as evidence that somewhere along the line of ownership and management there is a lack of understanding of the savings that can be made through the expenditure of moderate sums for first grade supplies and time saving equipment.

Cracks in boiler settings, warped fire doors, inoperative dampers, steam and water leaks are proof that indifference or neglect prevails. The problem is to find those responsible for these conditions and then drive home the facts in each case.

Plants as pictured above do not generally exist because the engineer on the job is negligent or ignorant; for invariably it will be found that his actions indicate that he is physically fit, his clothes show that he is the kind of man who gets right into the job and a brief conversation will prove that he is experienced and knows his business.

Where, then, can the responsibility be placed? In any number of cases it is the fault of the management because the engineer, always a busy man, is not provided with first grade supplies and time saving equipment and instruments. The engineer is too often spending much of his time in a fight to keep the plant operating at any cost rather than exercising his ability to improve general conditions and the economy of the plant. His job is made one of physical endurance rather than that of capitalizing for his employer through the use of his experience and brains.

Such equipment as feed water regulators, flow and temperature records are time savers for the engineer. Packing and general supplies should not be purchased through the office on price considerations only. Consult the engineer and profit by his experience, for in this way the cost of supplies will be reduced; many hours can be saved both on maintenance and operation, with the result that the engineer will have time to study and effect worth-while economies.

You can profitably spend to save.

[W. E. S.]

* Power Plant Engineering, Vol. XXVII, No. 14.

India Improving Cane Varieties Through Seedling Canes*

The results of mill trials on selected seedling canes in India, carried out by Mr. Wynne Sayer, Secretary of the Sugar Bureau, are given in the Agricultural Journal of India, May, 1923.

The seedlings which gave the most promising results were crossbred at the cane breeding station, Coimbatore, which was instituted by the Government of India about ten years ago. Three of the seedling canes originated by the station have had practical tryouts, and show their adaptability to conditions in Northern India, particularly in North Bihar, which has a large number of cane growers, and in which district a number of modern factories manufacturing white sugar are located.

Cane varieties adaptable to this district require unusual hardiness, as the cultivator of North India gives his cane indifferent treatment, and as a rule has not sufficient funds to expend on fertilization. Some seasons in this vicinity are most trying, and it is necessary for the canes not only to be resistant to drought, but to withstand intense heat, which frequently prevails in this district. Three of the seedlings were selected, showing desirable qualities, known as Co. 210, Co. 213 and Co. 214.

These varieties prove to be good drought resisters, and their behavior during the growing season is splendid. The hot weather in 1922 was very severe, a temperature of 110 degrees Fahrenheit was experienced on several days with high wind, but during this hot weather Co. 213 showed no ill effect; Co. 214 and 210 also stood it remarkably well.

After the rain these canes made rapid progress, and their superiority over the local canes was asserted early. These canes have a hard outer rind and are not subject to damage from fungus or insect pests to the extent of the damage from this source in native canes.

Mill trials of these three varieties were successful, showing larger yields in the field and increased yields in the factory over local canes.

By combining these varieties with local cane, the grinding season can be started earlier, which will be of marked advantage in extending the operations of the mills. These hardy and resisting varieties promise to be of marked value to the Indian sugar industry, and show the benefit of intelligent scientific treatment as now being applied in India to its sugar industry.

[J. A. V.]

* From the Louisiana Planter and Sugar Manufacturer, Vol. LXXI, No. 4.

Formosa Sugar Industry*

The sugar industry in Formosa, which according to the original program of the Taiwan government, was aimed to reach a production of raw sugar at least sufficient to supply the demands of Japan, received a great setback as a result of serious typhoons in 1911 and 1912. This caused great fear for the future of the sugar industry.

The Far Eastern Review in reporting these conditions, states that by the results of carefully carried out experiments and substituting for the Rose Bamboo cane,—which had proved adaptable to Formosa conditions and produced a high percentage of sugar, but was susceptible to damage from winds,—a type of cane which resisted the winds, these difficulties are now obviated. Seedling canes were imported from Java, which proved of sufficient resistance to wind damage and adaptable to Formosa conditions, to largely replace the Rose Bamboo cane. In 1918, 35 per cent of the area under cultivation was of this Java cane, and in 1922 this percentage had been increased to 87.7 per cent. Following the marked benefits derived from the Java seedlings, Dr. Ishida, Chief of the Sugar Division of the Central Research Laboratory, developed native seedling canes from the Java seedlings, one of these called F-19, has proved to have high wind resistance power, and is shown in experimental cultivation to yield more sugar than the Java cane. The success of this variety has led Formosa to greater developments with hopes of further improvement along this line.

Coincident with the improvement in the cane has been improvement in the agriculture of the island, particularly relative to the tenant-farmer system. The older methods of restricting tenancy of the farmer to one year resulted in extensive cultural methods. The government has now reformed these old regulations so that the tenant will have possession for a minimum of six years, this has resulted in a marked improvement of the fields by fertilizing and deep plowing. The farmers have exerted themselves to increase production and the yields have increased from 1913 to 1921 almost 250 per cent, with prospects of further increase.

Leading sugar companies are now applying new regulations encouraging early planting and selection of varieties, with the result of the increased yields above mentioned, and the cane grown stands the ill effect of wind and rain storms better than the previous varieties planted in that country.

The sugar expert of the government looks forward to doubling the present production in the next ten years, and predicts an increase, by the judicious selection of seed cane of 20 per cent; by scientific fertilization, 50 per cent; by irrigation and drainage, 20 per cent; and by control of insect pests, 10 per cent.

Recent results by the Research Laboratory have established the economic limit of fertilization, giving formulas for same, and the government is planning the construction of large reservoirs for irrigation purposes, which when completed will make possible the irrigation of large areas of upland, at present without a supply of irrigation water.

With the cooperation of the companies and the government, it is expected that the sugar industry will be firmly established on a new and sounder basis.

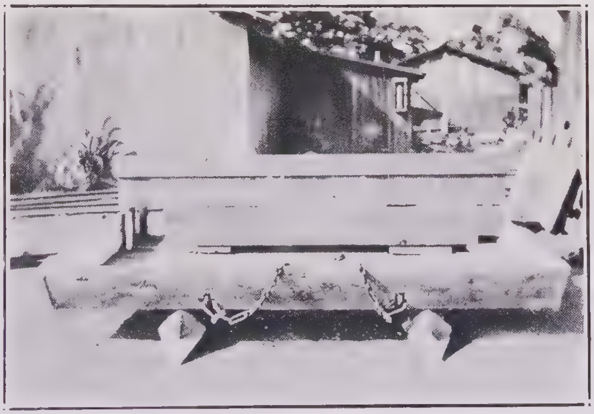
[J. A. V.]

* From "The Louisiana Planter and Sugar Manufacturer, Vol. LXXI, No. 4.

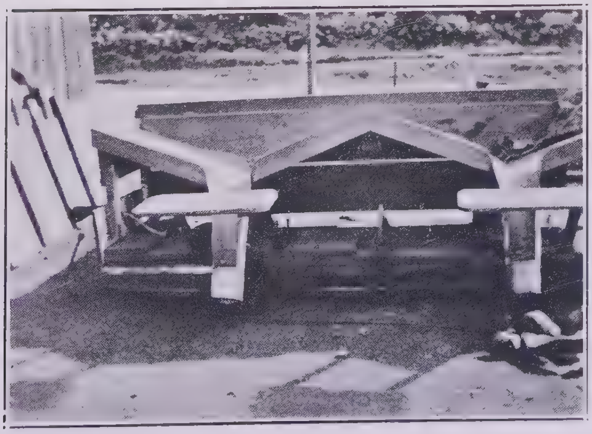
Plantation Notes—Illustrated

(Photographs by J. S. B. Pratt, Jr.)

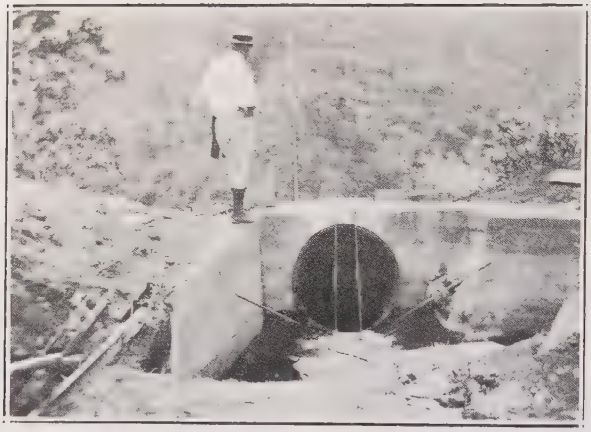
Hitch used at Makee. Front doubletrees are eliminated, animals turning easier, and starting off quicker—for hauling cane, harrowing, etc.



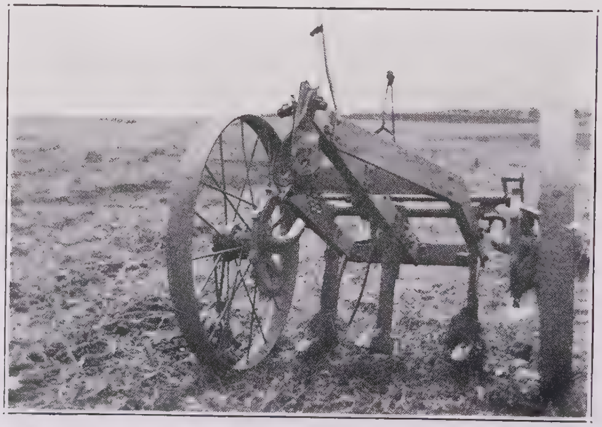
Broadbent sled for planting under unirrigated conditions, or for orchard system—front view.



Same as above — rear view. Two rows are planted. Note seat for boy while dropping seed.



Outlet of 1100 ft. syphon installed by Kilauea Sugar Plantation.



Kiliffer Subsoiler used at Kaiwiki Sugar Co.

Harrow used in grading portable track beds at Kilauea.

Loading station at Hamakua Mill Co. Lifting load from wagon to cars.

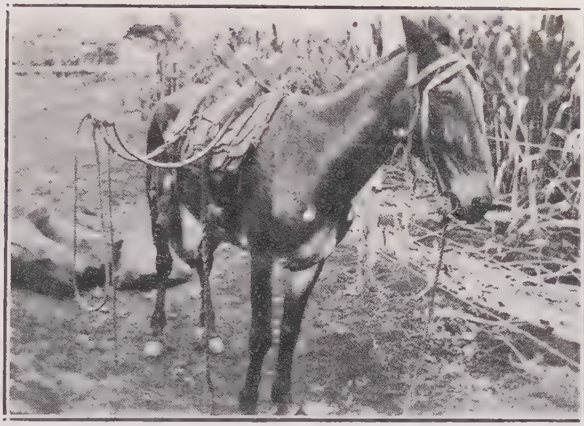
Uba cane grown without attention at Kilauea by roadside, instead of weeds and lantana.

Badila (left) and, Uba (right) at Kilauea.

Nine weeks old Yellow Tip ratoons at Makee. Seed of this variety was desired for mauka lands, so a few bags received from Pioneer were planted under the best conditions makai, cutting 15 to 1 in 8 months. Mgr. Wolters in picture.

Sled seen on Hawaii. Used to haul cane to flume from long packs.

Movable shed at Onomea to lock up gasoline in field for tractors. Could be used to store fertilizer in field.

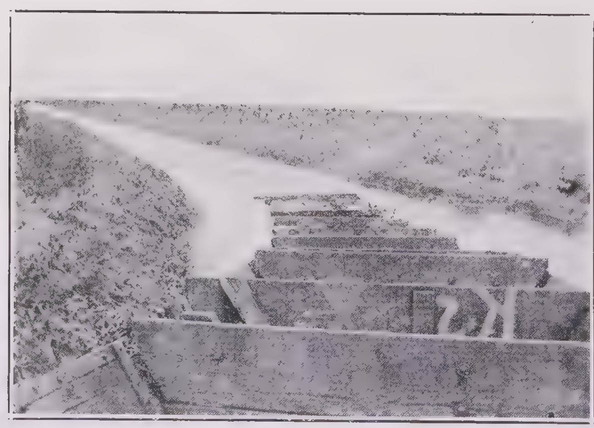


Type of packsaddle seen on several plantations. This one at Makee.

Applying mudpress in the furrow to ratoons.

Geri-geri implement used to break lumps in furrow before planting at Hilo Sugar Co.

Soaking seed at Koloa. Cars with seed are quickly run in on track placed in pond. Pieces of portable track put on top of seed to keep bags from floating.



Soaking seed at Kilauea. Much handling of seed is saved.

Riding disk cultivator at Kilauea.

Sugar Prices.

95° Centrifugals for the Period June 19 to September 15, 1923.

Date	Per Pound	Per Ton	Remarks
June 19, 1923....	6.905	$138.10	Cubas, 7.03, 6.78.
" 20	7.095	141.90	Cubas, 7.03; Philippines, 7.16.
" 21	7.28	145.60	Cubas.
" 22	7.53	150.60	Cubas.
" 27	7.16	143.20	Spot Cubas.
" 28	6.09	121.80	Cubas, 6.15, 6.03.
" 29	6.15	123.00	Cubas.
" 31	6.2167	124.33	Cubas, 6.15, 6.28; Philippines, 6.22.
Sept. 5	6.28	125.60	Porto Ricos.
" 10	6.465	129.30	Cubas, 6.40, 6.53.
" 11	6.65	133.00	Cubas.
" 12	6.75	135.00	Cubas, 6.72, 6.78.

ERRATA

Vol. XXVII, Nos. 1, 2, 3 and 4

Pages 108, 180, 256 and 373

Sugar Prices: 95° Centrifugals for the Period *should read* 96° Centrifugals for the Period.

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An asterisk preceding a page number indicates that the subject is illustrated.

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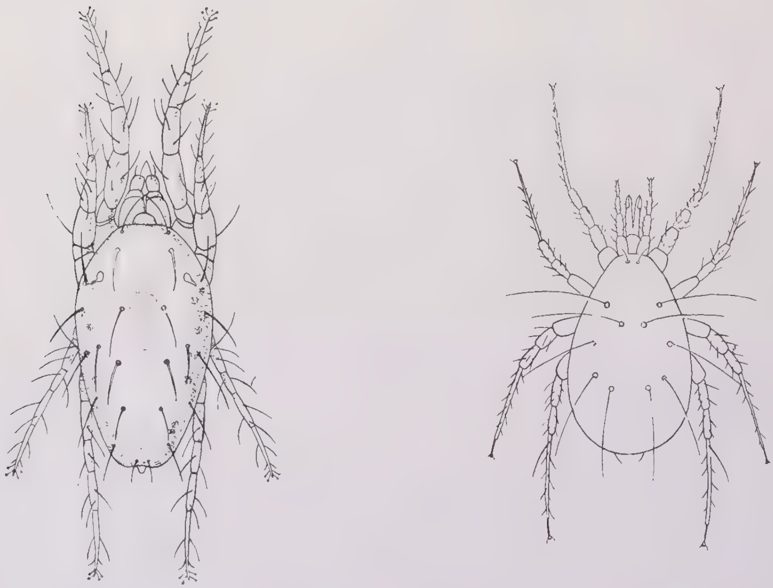
ILLUSTRATIONS APPEARING ON THE COVERS OF VOLUME XXVII.

No. 1.



The Java sugar cane leaf-mite, a newly recognized cane pest of Hawaii. At right, a predatory mite which was chiefly responsible for checking an extensive infestation of the leaf-mite during the summer of 1922. (Highly magnified.)

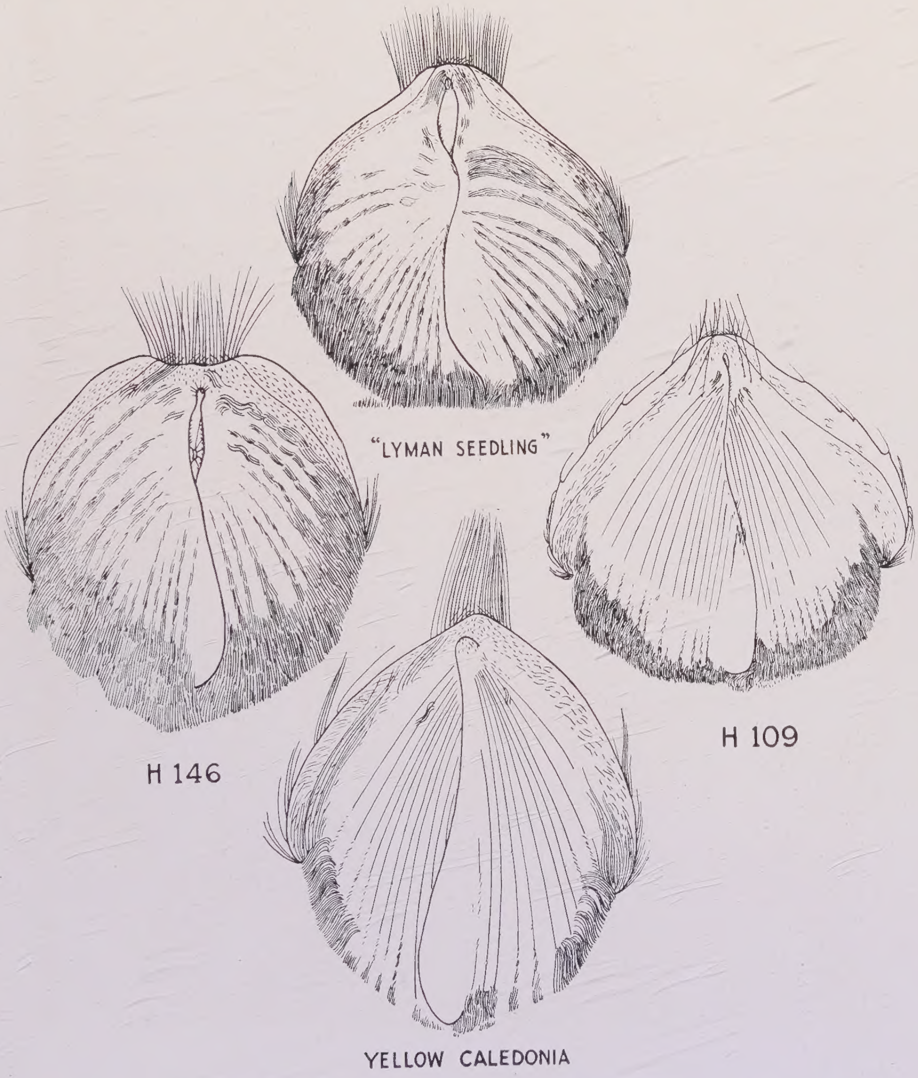
No. 2.

This stool of cane grew from a single-eye planting.
The variety is H 109.

No. 3.

Sugar cane seed magnified twenty diameters.
Variety H 109.

No. 4.



Eyes of four varieties of sugar cane magnified to show the hairgroups successfully used as part of the Jeswiet system of identifying individual varieties and tracing the parentage of seedlings.